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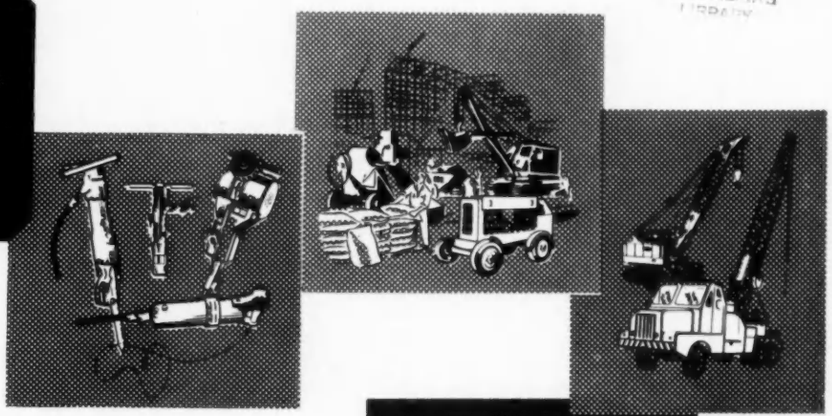

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'THE ENGINEER' BUYERS GUIDE Published annually. One FREE copy is sent to all direct postal subscribers on publication and delivered by newsagents to all regular readers. Additional copies are obtainable at 10s. 0d. each. Postage 2s. 0d. extra.

Published every Friday by

MORGAN BROTHERS (PUBLISHERS) LTD., AT 28, ESSEX STREET, STRAND, LONDON, W.C.2. Telephone : CENtral 6565

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THE ENGINEER

No. 5524 DECEMBER 8, 1961 Vol. 212

ROYAL SMITHFIELD

Our correspondent, who, following an inspection of the Smithfield Show in 1861, wrote in these columns, (albeit with his tongue in his cheek since the emphasis was patently on livestock) that farming was but a branch of engineering after all, would, were he alive and able to do the Smithfield rounds again, see no reason whatsoever to retract his words. True indeed, the cattle are still there, but progress — in the shape of mechanical beasts — has relegated the live beasts from their pre-eminent position to the role of an equal partner in the show. The same correspondent also felt constrained to refer, again in our columns, to Smithfield as "that temple of the herbivora fragrant with ammonia . . ." But we can testify, backed by such a worthy body as the National Society for Clean Air, that diesel fumes and other modern industrial effluvia have little to recommend them in favour of the more natural odour of the livestock.

That things are not what they used to be cannot be gainsaid, and the heterogenous array of intricate equipment at Smithfield this year bears witness to the fact that technology has been introduced "down on the farm". The days when a prod with a gnarled finger or a dig from the farmer's stick was sufficient to evaluate the amount of lean as opposed to fat carried by the humble pig are over. Nowadays — and we must confess even we were surprised — there is available to take over from the finger and the stick, "an ultrasonic echo-sounding instrument for measuring the back fat on pigs". We trust the pigs appreciate the lengths to which the engineering industry has gone on their behalf!

The Royal Smithfield Show holds as much interest for engineers as it does for farmers. Agricultural engineering offers an interesting challenge, for Mother Nature when vexed is still well able to "bog down" the most carefully designed machines. A great deal has been done in recent years towards mechanising many of the farmers' tasks, but this, in turn, has forced the farmer to take a new look at his responsibilities. Although machinery, carefully chosen and properly used, leads to more efficient and economic production, it brings with it other problems. It is expensive, and the expense is often difficult to justify when possibly the machinery's use may be limited to only a few days a year. It seems that the engineering industry is thus unwittingly causing more changes in agriculture than were visualised in the days when the iron horse took over from the hairy one. The smaller farming units are faced with a problem which each year grows more difficult to solve. While they remain small the problem remains. "Push-button" farming is bound to be expensive when it comes! The showing of a return on the capital invested depends upon making sufficient use of the equipment. The trend, pointed out and discussed at the Norwich meeting of the British Association for the Advancement of Science last September, is towards the creation of large farming units run on almost industrial lines.

EXPORTING TO EUROPE

Last week there was held at Eastbourne a great national Convention organised by the Export Council for Europe. Of its importance there can be no doubt. Amongst other prominent people the Prime Minister and the Chancellor of the Exchequer both thought time well spent in addressing the Convention. Some 430 of those present represented British industry and commerce, about 60 came from British embassies, chambers of commerce and similar bodies on the Continent. Government departments were represented and, of course, so were the sponsoring bodies, the Federation of British Industries, the Association of British Chambers of Commerce, the National Union of Manufacturers, the Trades Union Congress and the City of London. All who were present will look forward to the publication in due course of the full report of the proceedings.

Certainly the general impression created was one of enthusiasm. No wonder! Exporting to Western Europe is proving very profitable. So much so that in 1960 this country's exports to that region rose by twelve per cent compared to the year before, though imports rose even more by 19 per cent; and in the first ten months of this year exports increased by some 15 per cent and imports by only two. The Chancellor was encouraged to remark "You cannot force people at home to sell goods abroad . . . the first inducement obviously is the profit that can be made." Thanks to the work of the E.C.E. more and more firms seem to be discovering how profitable it is to get into the export business to countries whose standards of living are rising fast and in which the demand for many kinds of goods is consequently rising too. There are, of course, some snags. Not all British industries find they can compete with the home manufacturer in the market — not necessarily through inefficiency, there are special difficulties for particular products in certain countries. There is even evidence here and there of unfair practices prejudicing export business. But the general story at the Convention seemed to be of the "success" variety. Moreover the degree of knowledge displayed of the idiosyncracies of various markets made a good deal of nonsense of the criticisms one so

often hears of British salesmanship, of British lack of enthusiasm, and of British delivery delays.

We are technical people here; we do not pretend to be expert about the ins and outs of marketing, of market research, of pricing and costing, of packaging, of raising credit etc. But one thing did occur to us. It is surely not enough when venturing to enter an export market to send to the country concerned only high executives and those expert in sales procedures. If, for example, engineering goods are to be sold successfully in Western Europe they must be technically at least as good as those of competitors. We suggest therefore that whenever opportunity offers designers and production side people should be sent to the countries concerned to see what the conditions are, to see competing products and, if possible, to see the shops and the manufacturing methods of competitors. It is, of course, because we think it so desirable that technical people should thus visit Western Europe, that we always welcome a decision by any engineering society or institution in this country to take its members abroad for a Summer meeting or similar function.

CROSS-CHANNEL POWER LINK

The cross-Channel cable link now in service between the French and British electricity supply systems will have a capacity for the transfer of 160MW of power in either direction. This capacity is, of course, quite small compared with the magnitude of the two networks thus connected, but the importance of the link far transcends its mere size. In the first place it is a full-scale commercial demonstration of what can be done with high-voltage direct-current transmission of power and it foreshadows greater things to come. Today it is the largest installation of its kind in the world—eight times as large as its immediate predecessor and prototype between Sweden and Gotland. By 1965 it will be surpassed in size by the Cook Strait scheme, New Zealand, which will have a transfer capacity of 600MW.

But the immediate importance of the cross-Channel power link is that it offers commercial gains by the transfer of power, taking advantage of the difference between the incidence of peak power demands and exploiting the marginal differences in generating costs in the two countries. The economic case for the link is that each country can import, from the other, 160MW when required and can, therefore, save the capital outlay on 160MW of generating plant. Thus, with capital costs at about £50 per kilowatt, Britain stands to save about £8,000,000, whereas the total cost of the equivalent two-way cable link is only about £5,000,000. In addition it is calculated that the link will give an annual saving of £300,000 in operating costs compared with those of the additional generating plant that would otherwise be required. If such savings can be realised in dependable day-to-day operation, then, bearing in mind the natural growth of the British and French electricity systems, one may soon be arguing the case for augmenting the cross-Channel link to give it a transfer capacity of, say, 750MW or more.

MECHANISATION OF BUILDING

At the time of the Building Exhibition each year the Ministry of Works annually organises a discussion about some facet of building. This year the subject for that discussion, held at Olympia, on November 28, was "Design for Mechanisation". The building industry lags behind others in mechanisation. Consequently in listening to the discussion we kept hearing echoes of similar discussions held years ago amongst engineers. Mechanisation necessarily requires a degree of standardisation. But architects, like most people in engineering design offices a decade or two ago, tend to be individualistic. They feel themselves to be unduly constrained by standardisation; and, indeed, in some respects they may be. Mr. Grenfell Baines, the architect who opened the discussion, made play, for example, with windows, mass produced windows for the domestic house. He asked, too, whether houses and hospitals ought to look like schools. That he felt was one of the consequences of standardisation; it was killing variety. He went further. The power of earth-moving equipment to level a site was causing architects to design buildings for level sites instead of adapting design to suit the contours. Even that high building-maid-of-all work, the tower crane, came in for criticism. He disliked the feeling that architects were being called upon to design buildings that could be easily erected, that is to suit them to the qualities of tower cranes. Should the means dictate the ends, he asked? Should mechanisation dictate to architects what they should do? Ought one not to design for the occupants rather than to ease the task of the building contractor?

Two engineers next took the stage, Mr. E. J. Cook, of Richard Costains Ltd., and Mr. O. J. Masterman of Unit Construction Ltd. Both, as was to be expected, stressed the advantages of mechanisation. Both explained the savings in manpower brought about by mechanisation, the increase in output thereby made possible, the lowering of costs. Mr. Cook, in particular, stressed the need for the acceptance of mechanisation and the need to accept it at the design stage so that machines could achieve as nearly 100 per cent usage as possible. A high degree of mechanisation, he maintained, must now be accepted. Mr. Masterman also stressed that whether or not architects liked it mechanisation was going to be more and more adopted and that because it made building cheaper architects would have more and more usually to design for it. Our own mental comment here was that, in fact, architects in the past had to design to suit the building techniques of the day and that there is really nothing very revolutionary about asking them to do the same today. It does not seem to us, for example, that there is necessarily an antithesis between designing a building for erection by a tower crane and meeting the needs of its eventual occupants. Acceptance of this limitation by the architect, we suggest, may, in fact, lead to the design of a more interesting, not a less interesting building, and one better fitted for human occupation.

But it was the last speaker from the platform, Mr. Bruce Martin, another architect, who put into perspective the real problem facing architects. He made it very clear that far from reducing variety the effect of mechanisation is to increase it! Mechanisation, he stressed, is especially efficient on the factory floor and the trend should therefore be to reduce operations at the site as nearly as possible to the assembly of factory made pieces. New standardised factory-made components, he suggested, are being devised at the rate of hundreds per year; and the architect must get used to this profusion and design buildings to make use of these components. Standardised they may be; but just as the standardised letters of the alphabet permit us to build an immense number of different words and phrases so can the intelligent use of standardised parts lead to a more varied architecture than the world has even seen before. There

is nothing particularly new to engineers in Mr. Martin's conception; they already build a number of articles from television sets to motor cars by the assembly of standardised parts and produce varied results. But the concept does seem to set some problems for architects. It is not only that the number of materials and other products is apparently becoming so extensive that no one man, nor even perhaps organisation, can be cognisant of them all, nor that architects need to bear in mind at the design stage the qualities of the machines which contractors will use to erect a building, nor even that the design and construction of a large modern building makes such demands on human knowledge that a team of people is necessary to ensure that a satisfactory concept is arrived at; the very lack of limitation is itself likely to prove a handicap. Engineers are well aware that the more narrowly the purpose of any structure or device can be defined the easier it is to design, for the simple reason that so many alternatives which otherwise intrude can be quickly eliminated. We suspect this is true also of buildings. But architects are having to face a situation in which relatively to the recent past there is far less limitation on what they can do: they are suffering, we suggest, not from poverty brought on by mechanisation and standardisation, but *embarrassment de richesse*.

DIP. TECH. AND CATS

On another page of this issue we print some extracts from the Address presented by Sir Harold Roxbee Cox on the occasion of the Presentation of Diplomas and Diplomas of Technology at the Battersea College of Technology on Wednesday of last week. Sir Harold discussed the Dip. Tech. and that other award of the National Council for Technological Awards, Membership of the College of Technologists, and what he had to say served a very useful purpose in recalling to his audience what were the objects of the Council in setting up those awards and indicating how attractive to young people Dip. Tech. courses have already become. Six years after the Council was set up there are now 5000 students following courses leading to the award of the Diploma. Sir Harold stressed that from the outset a Diploma course was intended to be of Honours Degree standard; but that it was never suggested that it should be like an Honours Degree course. All the same it would, he implied, be silly to be different just for the sake of being different. Nor should there be any idea of "competition" between universities and colleges. "They represent different approaches in education and they must both develop naturally, developing differences and developing similarities." His next hope was that if and when (as seems very likely) the Colleges become autonomous, so that they can make awards in their own right, they will continue to award Diplomas. How much he should be applauded! There are those who would call the award a "Bachelor of Technology". But why ape the universities? The Colleges are intended to be much more closely linked to industry than are the universities and that linkage will be reflected in their courses. The name of the award should therefore surely be distinctively different from that given by a university and the Colleges should be proud to make it different! Its prestige will depend on the successes of those who hold the award, not on any resemblance in sound to a university degree. Perhaps within a few years the term diploma-engineer will creep into the English language carrying with it a prestige at least as high as that which it carries in Germany to-day. What Sir Harold did not refer to is the fact that some of those who work in Colleges of Advanced Technology object to the name because it can be contracted to CAT. This seems to us unduly touchy. We have a great respect for cats.

ENVIRONMENTAL ENGINEERS

On Wednesday of last week we attended the second annual dinner of what is still a small Society. It is called the Society of Environmental Engineers; and we confess that one of the reasons why we found the invitation attractive was that we wanted to know what kind of animal an environmental engineer is. We were a little disappointed. We sensed that perhaps the IQ of those present was somewhat above average; the age below it. Otherwise environmental engineers looked remarkably similar to any other engineers. Upon enquiring more deeply we were presented with a document purporting to explain the objects of the Society. It opened with the remark "The Society was formed in 1959 at the request of senior engineers and scientists to establish a forum for the exchange of views and experience in the environmental/vibration field." Elucidation still seemed to be needed but was not easily obtained. It came at last when a member realised in what our confusion lay. The word environment is to be bereft of human connotations. What the members are concerned with is the behaviour of materials and devices in the service environment: hence the relevance of vibration which is suffered by so many parts of so many machines. Curiosity once satisfied we enjoyed the dinner. The speeches were irreverent, irrelevant, or just plain unprintable. The Secretary's office is at Suite 7, 167 Victoria Street, London, S.W.1.

The Engineer—100 Years Ago (DECEMBER 6, 1861)

Engineers and Contractors

"It would be interesting to know," we wrote, "how much of our practice of engineering is due to the professional engineer, and how much to the contractor." We felt that many of the contractors could more easily dispense with the engineers than the engineers could with the contractors and that if the contractors were disinterested, they might well be left to do their own engineering in many cases. But we also believed that the interests of the contractors were by no means identical with those of their employers, and it appeared necessary to set over them some representative of the latter, who should not only be competent to reject the work done, but also be competent to do it himself. The contractor should never get the start of the engineer, who should always know how to execute his own plans, and what they ought to cost.

With really good engineering, we thought, there should not be opportunities for contractors to make ". . . such large fortunes as they do." We did not regret their success, but regarded the fact that they were so successful as ". . . clear proof that they get the better of the engineers." Too often, we thought, the engineer asked a contractor if a thing could be done, instead of giving him a simple order to do it. How many young men, we asked, are taught, or have the opportunity of finding out, how their ". . . handsomely drawn and nicely coloured designs are to be carried out in practice?" It was true, we concluded, that there was so much specialisation and division of labour that it ". . . may become difficult to say what is an engineer" (prophetic words), but we did lay down that none of the proper functions of the engineer should be delegated to the contractor.

Cosmic Electrical Discharges or "Gobs of Anti-Matter"

by C. E. R. BRUCE

Several new developments of the electrical discharge theory are discussed, including the theoretical calculation of the energy radiated by radio-galaxies, which is in accord with estimates based on observations of the amount of energy radiated by Virgo "A." The theory also leads to a quite definite argument against continuous creation, and led also to the prediction that spiral nebulae should exist on a stellar, as well as a galactic, scale, a prediction which is soon verified, thanks to a suggestion from a friend at Mount Wilson Observatory, by reference to a paper published forty-two years earlier at Lick Observatory. Indications are given, where possible, of the suggestions which other theories have to offer for the phenomena discussed.

READERS of this writer's two earlier articles* (referred to as "A" and "B" hereafter) will recognise in the title of the present article a reference to one suggestion put forward by two astrophysicists, Hoyle and Burbidge, to explain the huge amount of energy radiated by a radio galaxy, such as Virgo "A," illustrated in Figs. 2 and 3 of Article "B." They wrote "Astrophysicists have been at a loss to account for its extremely strong radiation, and it is tempting to suppose that the energy is coming from the galaxy's capture of a gob of anti-matter from an anti-galaxy." In comment the writer wrote that "in this, as in other fields, some are more easily tempted than others, but the nature of the suggestion underlines the difficulties which these new observations present to existing astrophysical theories."

The problem of the energy radiated by Virgo "A" continues to exercise the minds of astrophysicists, and one of the above authors, Burbidge, recently regaled us in three and a half pages of *Nature* with an alternative suggestion. This is that the energy derives from stellar explosions triggered off by other stellar explosions, in a gigantic and glorious galactic "Brock's benefit night," which seems to the writer merely to underline his earlier comment.

2. Radio Galaxies and Stellar Populations

In the original outline of the electric field and discharge theory—a pamphlet entitled "A New Approach in Astrophysics and Cosmogony" published in 1944—it was pointed out that the stars in a galaxy should be, and apparently are, separated into two populations. Soon after this, Baade at Mount Wilson announced his discovery of the existence of the two Stellar Populations in our galaxy. The discharge theory now affords an explanation of their existence, and, so far as the writer is aware, the only one.

Contemporaneously with the building up of the electric field in the galactic atmosphere—which, as we shall see, requires 10^9 to 10^{10} years, as compared with the 10^7 to 10^8 seconds required in stellar atmospheres, and the 10^2 seconds required in thunderclouds—some of the gas and dust coagulates into one of these populations of stars, Baade's Population II. These are formed throughout the whole globular or ellipsoidal volume originally occupied by the whole galactic atmosphere, and, as observation confirms, are thus the oldest stars. In globular and elliptical nebulae of Hubble's Types E0 to E7, Fig. 1, in which electrical breakdown has not yet occurred, these are the only stars present. When breakdown does occur, magnetic pinch effect, as we saw in article "B," causes the gas and dust to be collected along the discharge channels, which become the spiral or irregular arms of the galaxy. There, in this gas of greatly increased density, a second population of stars, Baade's Population I, is formed relatively quickly.

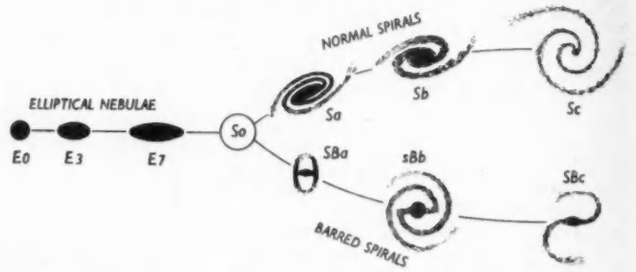

Fig. 1—The sequence of nebular types (Hubble)

There are two pieces of evidence which strongly support the new theory. It was pointed out in the same article that the only limitation to the increase in discharge temperature in these successful cosmic ZETAs, is the onset of thermonuclear fusion processes. These will increase the gas pressure and tend to balance the inwardly directed movement of the gas caused by the magnetic pinch effect. One result will therefore be that, since the gas which ultimately goes to the formation of Population I stars has been subjected to this "thermonuclear" temperature of the order of 500,000,000 deg. K. for a period of the order of 50,000,000 years—a time deduced from the length of the discharges and their velocity of propagation—it is to be expected that the proportion of heavy atoms in the gas will have been increased in the process. The proportion in Population I stars should therefore be greater than that observed in Population II stars, despite the fact that the latter are by far the older. In accordance with this theoretical "prediction," the proportion of heavy atoms in Population II stars is only 0·003; that in Population I stars is 0·03.

This observation leads to a further check of the theory since it enables us to calculate the energy radiated during the life-time of a radio-galaxy, during which, as we have seen, a fraction of the order of 1 per cent of the H atoms are transformed into He and heavier atoms. In the process about 1 per cent of the mass of these atoms disappears, so that it is to be expected that during the period of the discharges, when the galaxy acts as a radio-source, about 10^{-4} of its total mass will be radiated as energy of all wavelengths. The average galactic mass is that of about 10^{10} suns, or of the order of 10^{43} gm, so that on the discharge theory the energy radiated during the life of a radio-galaxy should be equivalent to a mass of 10^{39} gm or about 10^{60} ergs.

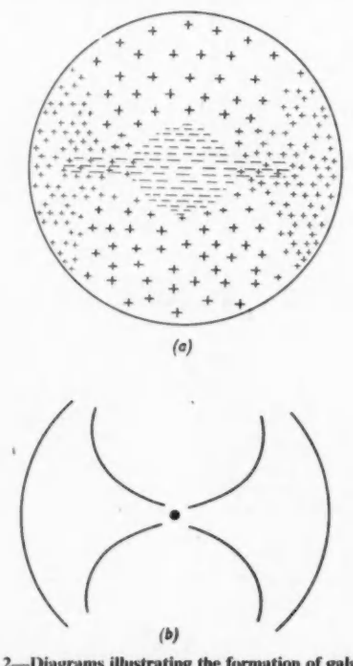

Fig. 2—Diagrams illustrating the formation of galaxies of Hubble's type SBa

Estimates have been made of this energy based on observations of the energy radiated by the radio-galaxy Virgo "A," already referred to, together with the estimated life of a radio-galaxy of 10^7 to 10^8 years. The value so obtained, 10^{58} ergs, is less by two powers of ten than that derived from the discharge theory. However, this is just about the factor by which the length of the arms in a spiral galaxy exceeds that of the "jet," or discharge channel, in Virgo "A" (Fig. 3 of Article "B"), in which electrical breakdown is in its very early stages, so theory and observation agree once more.

So far as the writer is aware there are no other explanations for either the existence of the two stellar populations or for the observed difference in their chemical composition. It is hoped that, in addition to the overall check afforded by the above energy considerations, it will be possible to calculate the latter from the characteristics of the discharge.

3. Irregular Galaxies

The existence of irregular galaxies has likewise remained unexplained until the advent of the discharge theory. That the latter affords an explanation was shown in a recent E.R.A. report, and in a forthcoming paper in the Journal of the Franklin Institute. The first point to be noted is that, apart from the irregular shape of the "arms," the irregular nebulae are identical with the spirals. That is, the arms contain gas and dust and Population I stars, and are threaded

* THE ENGINEER, August 17, 1956 and December 25, 1959.

Fig. 3—Interacting galaxies

through a background of Population II stars. It follows that they must have been formed by the same processes which formed the spiral nebulae, and as this cannot have been rotation, the latter cannot have been the cause of the spiral arms either, though it is the one which has hitherto been vaguely invoked for the explanation of the spiral structure.

The solution to this problem probably lies in the amount of residual angular momentum in the gas which originally went to the formation of the galaxy out of the primordial universal atmosphere. If this is very small, then the gas will still have an approximately spherical or globular form when the radial electric field reaches the breakdown value. Once breakdown is initiated there will be no preferred direction, and the shape of the discharge channels will be determined by random concentrations of space charge, so that the result may be quite an irregular pattern of discharge channels.

4. Spiral and Barred-Spiral Galaxies

On the contrary, if the gas originally possesses a large amount of angular momentum, it will assume an ellipsoidal form. The resulting diametral plane will not only be that of maximum angular momentum, but also of maximum electric field, so that breakdown will be initiated in that plane, and the discharges will remain in it. They may well remain radial, in which case the result will be a barred-spiral nebula, but if one of the discharge channels is deflected by a concentration of space charge then the distortion of the electrostatic field at the advancing tip of the other discharge channel will be such as to cause it to turn off in the opposite direction, and the result will be a spiral nebula.

Support for this view is afforded by the existence of barred nebulae of Hubble's Type SBa, Fig. 1, usually referred to as barred-spiral galaxies, though the arms would appear to be arcs of circles rather than spirals, and indeed the structure of this type of galaxy would appear to be entirely different both from those of spirals and barred-spirals.

To understand this form we consider what happens if the deflection from a radial channel is indefinitely delayed. The discharge represents a short circuit of the radial electric field, so that large electric field concentrations and therefore large concentrations of space charge, are built up around the advancing tips, Fig. 2a. As the latter approaches the confines of the galactic atmosphere, the electric field ahead of the discharge will approach zero, and lateral breakdown will occur around the confines of the atmosphere, but still in the diametral plane, so that the result will be arms of the shape shown diagrammatically in Fig. 2b. This will be seen to agree with Hubble's Type SBa, which would again appear to be impossible of explanation on any rotational basis. We shall see that this is a very common, indeed probably the commonest, form of nebula which results from the occurrence of the corresponding phenomena on a stellar scale.

5. Interacting Galaxies

Radio observations have recently led to a more accurate determination of the structure of our own Galaxy, and it has become apparent that there is a tilt in the Galactic plane towards the Magellanic Clouds. One speaker at the International Astronomical Union's Third Symposium on Cosmical Gas Dynamics in 1958 had referred to this as a possible tidal effect. In the discussion he was asked to comment on this, and in particular if it could be explained as a gravitational effect of the two Clouds. He replied as follows: "... the distortion observed .... is too large by about two orders of magnitude to be explained by gravitational effects. But really I am not surprised. We see such enormous distortions in many galaxies, and bridges between galaxies, and also more fancy things which cannot possibly be explained by gravitation, neither in order of magnitude nor even qualitatively in shape." Such is the state of existing astrophysical theories! Yet the formation of electric fields in cosmic atmospheres and the electrical discharges to which they lead are still considered "quite impossible"!

Fig. 3 shows one of the "fancy things" which the speaker probably had in mind. When one recollects that currents will flow along and not across any magnetic fields they may encounter in cosmic space, it will be appreciated that the lateral extensions of the lower galaxy are just such as would be formed by the two discharges in it, when forced to turn along the magnetic lines of force due to circular or spiral currents in the upper galaxy.

A more homely example of this complete "outclassing" of gravitational forces in electrical discharges was referred to in the title of article "B," "Arc Welding and the Galaxies," in which it was shown that the jet of gas engendered by the arc discharge blows the globules of metal from the rod to the "job." The process is therefore quite independent of gravitational forces, as every welder knows.

6. Galactic Evolution and the Cosmological Controversy

Hubble's scheme of galactic evolution is illustrated in Fig. 1. The new light which the discharge theory throws on this scheme, and on the major cosmological controversy as between continuous creation or an evolutionary universe, derives from a consideration of the times required for the build-up of the electric field to breakdown in galaxies of different sizes. It was emphasized in Article "A" that even the problem of the charge generation and separation in thunderclouds is still without an agreed solution after over 200 years of theoretical and observational study. By so much the less can we deal adequately with the building up of stellar and galactic atmospheric electric fields. Indeed since that earlier article was published a quite new theory of the phenomena in thunderclouds has appeared, which its authors claim is the only one capable of accounting for the observed rate of charge separation.

It may well be that this theory may yet make a contribution to the solution of the problem of the generation of electric fields in cosmic atmospheres.

However, for the time being the general arguments used in the earlier article to estimate the order of magnitude of the time required in stellar atmospheres (10^7 to 10^8 seconds), as compared with that observed in thunderclouds (10^2 seconds), lead us to expect that the time required in galactic atmospheres will be much greater still, and that this time will increase with the size of the galaxy. On this view it is therefore to be expected that, the smaller the galaxy, the longer ago will the breakdown field have been reached, and the better defined will be the spiral arms in the galaxy, galactic evolution being on the discharge theory in the direction $EO \longrightarrow E7 \longrightarrow Sa \longrightarrow Sb \longrightarrow Sc$. The theory therefore leads us to expect an increase in the average size of the galaxies in the opposite direction to the above sequence of galactic types, i.e. from Type Sc, through Type Sb to Type Sa, and that Types EO to E7, in which the discharges have yet to occur should be the biggest of

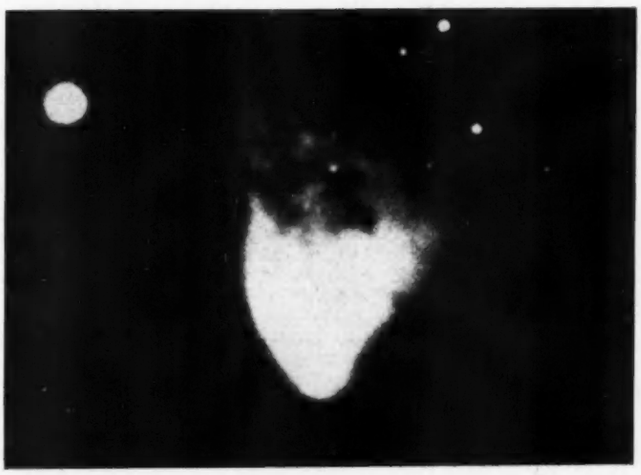

Fig. 4—Hubble's variable nebula

all. The interesting new fact is that this theoretical expectation accords with observation. Galaxies are found to increase in size in the direction Sc–Sb–Sa–E. This has, however, been misinterpreted, in the writer's opinion, as indicating that individual galaxies increase in size and evolve in this direction, whereas individual galaxies actually evolve from EO to Sc, but at different rates according to their sizes.

The important conclusions to be drawn from these considerations are that there still exist galaxies in which there has not yet been time since " Creation " for the electric fields to build up to the breakdown value ; creation is therefore not continuous, and the time required for the build-up of the electric field in the largest galaxies is greater than 10^{10} years.

It may be emphasized that whereas the discharge theory thus affords for the first time a logical scheme of galactic evolution, the alternative view is entirely hypothetical. It assumes, for example, that the initial stage of a galaxy is one with the arms well defined, Type Sc or SBc, developed by some process entirely unknown, which, as we have seen, cannot be rotation. These well defined arms are believed to gradually disperse. However, the whole idea is too nebulous to require much criticism ; there is very little to criticize.

It is even contended today that Hubble did not intend his diagram, Fig. 1, to be taken to represent the direction of galactic evolution. However, he did write that there is an indication of the occurrence of some " cataclysmic action " at SO, " this critical point in the evolutional development of nebulae," a role which the galactic discharges will be seen to fill adequately. Again he emphasized—also in " The Realm of the Nebulae "—that " Sa spirals are always found with the arms fully developed " (page 46), and several times comments that the arms are never seen in process of development, indicating that he believed, as does the writer, that evolution is in the direction EO to Sc, and not from Sc to EO.

It may be pointed out that the radio source Virgo " A," already referred to, is a globular nebula of Type E in which the breakdown process has recently started, the discharge channel being a mere 300 parsecs (6,000 million million miles) long, as compared with an average galactic diameter of tens of kilo-parsec. These are the relative dimensions referred to at the end of section 2.

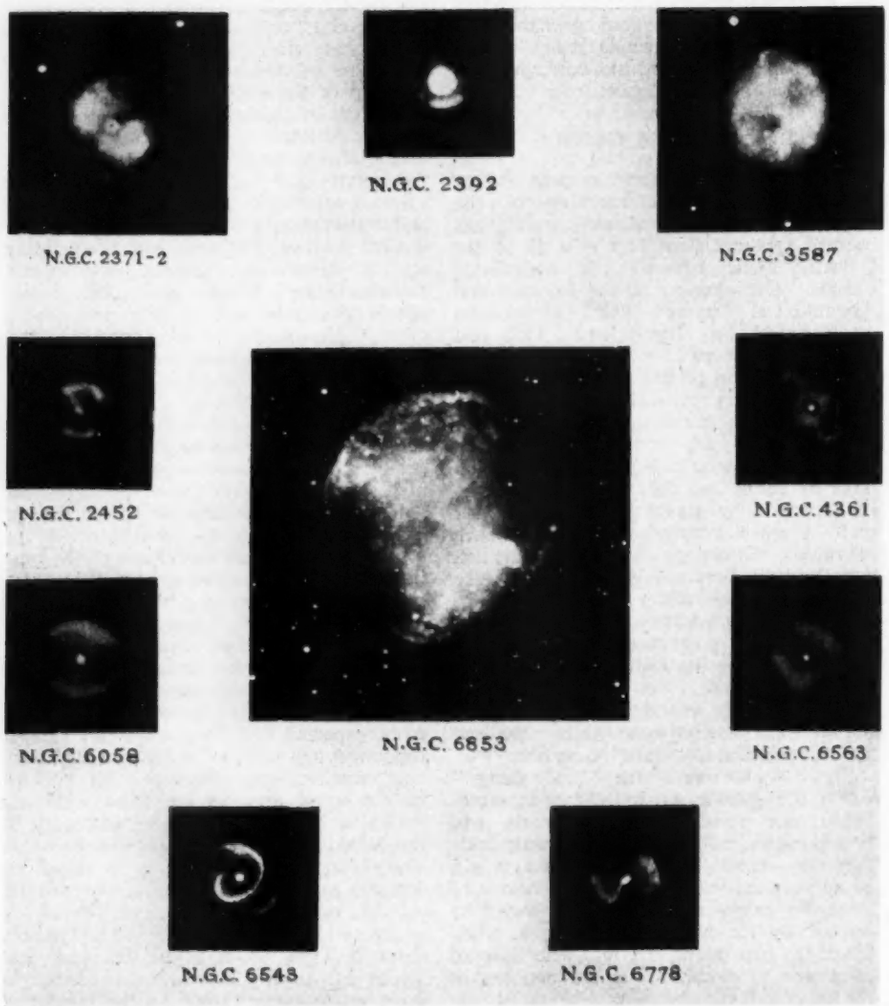

Fig. 5—Photographs of planetary nebulae showing pairs of old discharge channels (H. D. Curtis)

7. Spiral Stellar Nebulae

In a recent lecture to the British Association, Professor Bondi suggested that theories should " live dangerously," by making outstanding predictions, which can then be verified, or not, by observation. In the last article (" B ") the writer deduced that temperatures of about 400,000,000 deg. K. must be reached in some solar atmospheric electrical discharges, which seemed to be sticking his theoretical neck right out, since the highest temperatures then recognised were the one to five million degrees of the solar corona. However, within a few months he was able to report the success of this surprising prediction. (See The Engineer, January 29th, 1960).

It is now his privilege and pleasure to report the success of another equally striking prediction, that of the existence of spiral nebulae on a stellar scale. This derived from the explanation which the electrical discharge theory offered for two types of stellar spectra, which have been the subject of much study, both observational and theoretical. In the first of these, named after the star P Cygni in which they have been most intensely studied, notably by Dr. C. S. Beals, Dominion Astronomer in Ottawa, the main features of their spectra are bright emission lines displaced from their normal positions towards the violet end of the spectrum, by motion of the emitting hot gas toward the observer. It seemed to the writer that these could be explained if P Cygni had a cometary nebula, like Hubble's Variable Nebula, (Fig. 4), but directed towards us. This photograph has the additional interest that it was the first official photograph taken by Hubble himself on the new 200in Telescope at Mount Palomar Observatory on January 26, 1949. On the discharge theory this nebula is the result of an earlier nova outburst in its atmosphere—an electrical discharge by which its atmospheric matter has been gathered along the discharge channel by magnetic pinch effect. In the region of relatively high gas density thus formed, thunderstorm conditions become almost continuous, causing the observed variability of the nebula's light. In accord with this suggestion, P Cygni is known to be an old nova. As was shown in Article " B " these discharges will cause the gas to be squirted radially outwards, so that, as happens in the long-period variables, the bright emission lines in their spectra, from the hot gas, will be displaced towards the violet, if the discharge is directed towards us in the line of sight. Here it may be mentioned that, though the commonly accepted explanation of the P Cygni type of spectrum is that it is due to an expanding spherical envelope of hot gas, Dr. Beals recently informed the writer that he is coming to the conclusion that this explanation is not satisfactory, and that jets of gas are probably involved, somewhat as suggested by the writer's discharge theory.

Now there is another well-known type of stellar spectrum in which the emission lines are double, one component being displaced to the violet, as in the P Cygni spectra, and one to the red end of the spectrum. The explanation just given suggested that this second type of spectrum could similarly be explained if stars existed with two diametrically opposed nebulae of the type of Hubble's Variable Nebula, and if these were more or less in the line of sight. Since Hubble's Variable Nebula is readily photographable, it seemed highly probable that photographs of these double nebulae would exist. Surprisingly enough enquiries of a number of astronomical friends drew a blank, even from those who have actually worked or are working on the planetary nebulae, until the late Dr. Merrill of Mount Wilson Observatory suggested that the only place they might be found would be in a paper published at Lick Observatory in 1918. Reference to that paper by H. D. Curtis showed a profusion of just such double nebulae as the theory had suggested should exist, if the

above explanations are correct, and a few are shown in Fig. 5. The exciting new development was that, as well as comprising many nebulae of Hubble's Type SBa discussed in Section 4, (see NGC 3587, 6058, 6563), there were several examples of ordinary spiral nebulae (see NGC 4361 and 6543) and barred-spiral nebulae of his Types SBb and SBc (see NGC 2452 and 6778). This duplication of the phenomena on these two widely differing scales, and particularly the existence of both stellar and galactic nebulae of Type SBa, would appear to offer the strongest support for a common origin for the phenomena, and for the electrical discharge mechanism in particular.

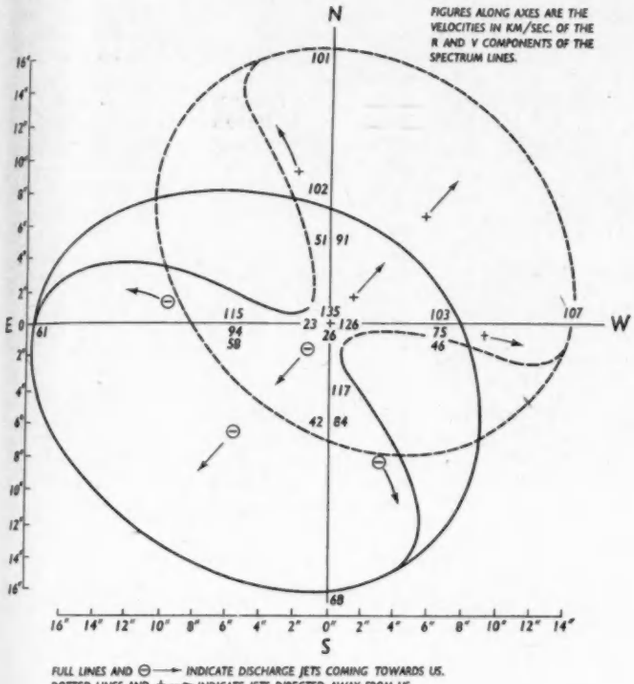
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Fig. 6—Diagrammatic representation of the gas jets in NGC 2392

8. Gas Movements in the Planetary Nebulae

It was, as we have seen, the general explanation which the discharge theory offered for the gas movements indicated by certain stellar spectra, which led to the discovery, or re-discovery, of the existence of spiral nebulae on a stellar scale. In contrast these same gas movements had led previous investigators to conclude that "We have found no hypothesis which seems competent to explain all of the observed facts."

It is therefore of interest to examine in more detail the gas movements in two nebulae—NGC 2392 and NGC 6543—of a group of ten which called forth the above comment. The gas velocities observed with the slit of the spectrograph along the major and minor axes of the former nebula are plotted in Fig. 6 and will be seen to be at once explicable in terms of the two jets of gas engendered by the two straight discharge channels. The effects of the two jets are seen superposed except where they are separable in the NE and SW quadrants. For NGC 6543 it is not convenient to plot all the measurements since results are given for ten positions of the slit. However, average values are given in the circles in Fig. 7 and will be seen to be accounted for by two spiral jets of gas, a conclusion confirmed by the photograph of this particular nebula in Fig. 5.

If these nebulae have the discharge channels in the line of sight, then the result is the roughly circular outline shown by NGC 2610 (Fig. 8a) and NGC 6720 (Fig. 8b), the latter being the well-known Ring Nebula in Lyra. It is this type of photograph which

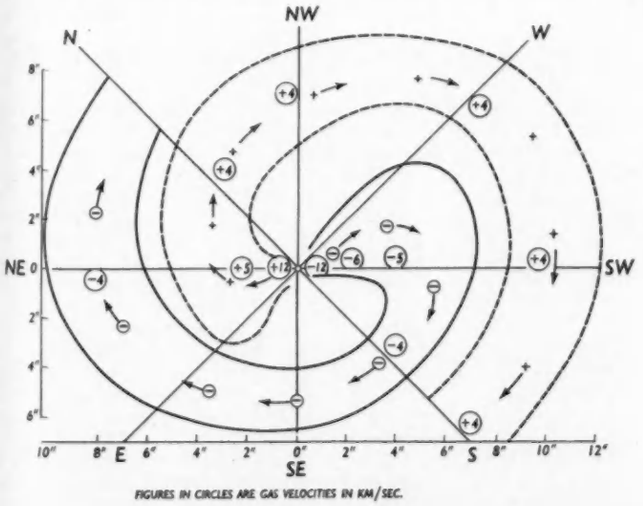

Fig. 7—Diagrammatic representation of the gas jets in NGC 6543

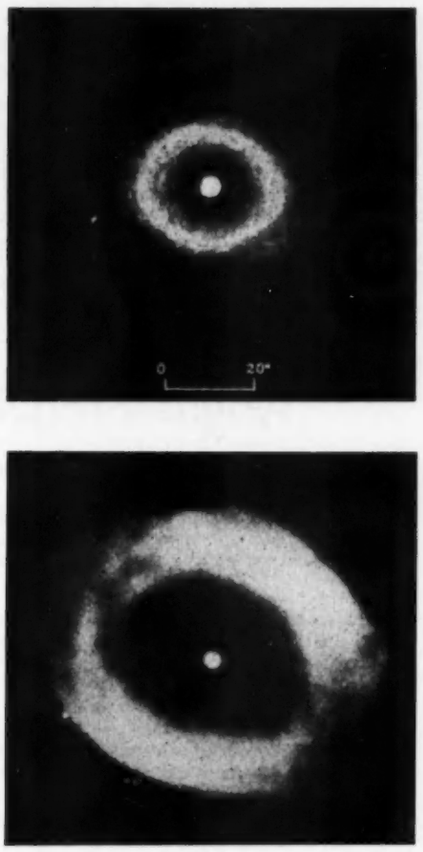

Fig. 8—Photographs of planetary nebulae in which the discharge channels are seen end on. (*a*) NGC 2160; (*b*) NGC 6720

is usually illustrated in textbooks, and has led to the theoretical consideration of the excitation of a fairly uniform atmosphere by the light from the central star. It will be seen that such treatments describe conditions which do not accord at all with reality.

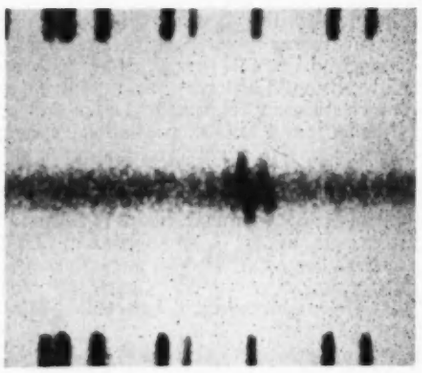

Fig. 9—Photograph of two lines in the spectrum of the barred spiral galaxy NGC 1097

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It is of interest that the corresponding gas movements have recently been observed on a galactic scale, when the slit of the spectrograph was oriented along the bar of the barred-spiral galaxy NGC 1097. The emission lines each comprise two displaced portions separated by the nucleus, (Fig. 9), and the authors' measurements show that the gas velocity is constant along each side of the bar, but that those on the two sides differ by about 415km per second. However,

they loyally suggest that these observations can in some way be accounted for by rotation of the gas.

9. Cosmic Electric Fields

The results described in the present paper and its two predecessors seem to the writer amply to demonstrate that after 300 years of gravitation plus a collection of *ad hoc* hypotheses which become more bizarre as the observed phenomena increase in complexity, order can be restored amidst the resulting theoretical chaos by the introduction of a new factor in the study of galactic problems—electric fields and the discharges to which they lead. Perhaps some would wish to emulate our friends in the U.S.S.R. and suggest that all this was originated by an Englishman, Sir John Herschel who, in 1868, made one of his characters, Hermione, remark " In the beginning was the nebulous matter, or Akasch. Its boundless and tumultuous waves heaved in chaotic wildness, and all was oxygen, and hydrogen, and electricity." However, the writer prefers to claim it as the work of a Scotsman who, in 1944, somewhat ebulliently wrote of " A New Approach in Astrophysics and Cosmogony."

Anglo-French Power Link

The cross-Channel d.c. cable link, with a converter station at each end, designed for transfers of power up to 160MW in either direction between England and France, is being formally inaugurated to-day. The following description deals mainly with the converter stations, each of which houses two groups of bridge connected mercury-arc valves giving a voltage of ±100kV on the cables.

THE cross-Channel cable link between the British and French electricity systems provides for the interchange of blocks of power up to 160MW in either direction taking advantage of differences in the incidence of peak loads in the two countries. Including the converter stations and cables the cost of the scheme is expected to be about £5,000,000. This figure will be more than offset by the saving of 160MW of generating plant which would otherwise have been required—at a capital cost of about £8,000,000. In addition the annual operating costs of the cable link are expected to be £300,000 lower than those of the equivalent 160MW power station.

The arrangement of the cross-Channel d.c. cable link between the British and French electricity supply systems is outlined in Fig. 1, and the main particulars are tabulated below, together with the corresponding data for the existing Gotland scheme and for the projected Cook Strait scheme in New Zealand.

Briefly the cross-Channel link consists of two submarine cables crossing the English Channel over a 34-mile route between Dungeness and Le Portel near Boulogne ; a converter station connected to each end of the cable ; and an a.c. substation at each end, to connect the converter station to the national supply network.

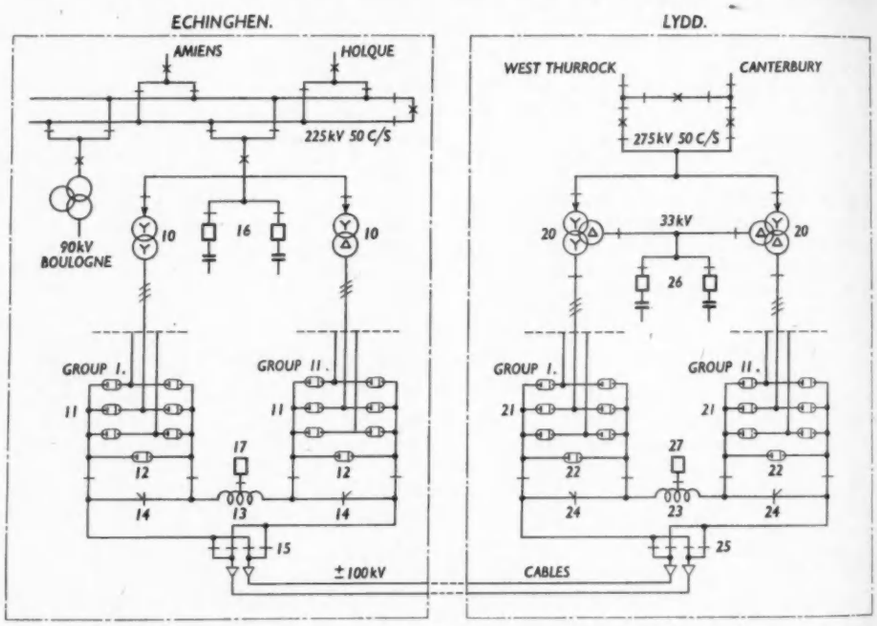
Both the a.c. substations, British and French, are outdoor installations of orthodox design. In Britain a double-circuit 275kV overhead line connects the a.c. substation to the Supergrid system via Canterbury and West Thurrock. On the French side the link with the national system is by overhead lines to Amiens and Holque. The British converter station and substation are sited at Lydd. The corresponding French installations are at Echingen a suburb of Boulogne.

In the converter stations the valves and certain auxiliaries are housed indoors but most of the rest of the equipment is installed outdoors in the adjoining compound.

The two converter stations are very similar, with minor differences, which will be referred to later. At Lydd the valves (Figs. 2, 3 and 4) are arranged in two groups, each consisting of six valves in a bridge connection, with a seventh (by-pass) valve as shown in Fig. 1. In the event of a momentary interruption in the operation of any one valve in the bridge circuit, the function of the by-pass valve is to take over and maintain circuit continuity. As the two groups of valves are connected in series on the d.c. side and as the converter transformers on the a.c. side are connected in star-star and star-delta respectively (Fig. 1), the valves suffer an electrical phase displacement giving the effect of twelve-phase operation for the two groups. Either group can operate independently in an emergency, in which event the system could continue to operate, but at half its normal output.

Mercury-Arc Valves

Many years of development work by A.S.E.A. with the help of Swedish State Power Board are embodied in the valves. Basically each valve is a mercury-arc converter with grid control. The main difficulty has been to establish sufficient control over



10, 20—Converter transformers.
11, 21—Six ionic valves.
12, 22—By-pass ionic valves.
13, 23—Smoothing reactor.
14, 24—By-pass switches.
15, 25—Cable isolators.
16, 26—Damped and resonant filters.
17, 27—Earthing impedance.

Fig. 1—Main circuit diagram for the cross-Channel connection 160 MW, ±100kV D.C.

Table—*Particulars of Cross-Channel Power Link compared with those of the Gotland and Cook Strait Schemes*

	Gotland	English Channel	Cook Strait
Power link	Gotland	English Channel	Cook Strait
Commissioning	1954	1961	1965
Power transmitted	20MW	160MW	600MW
Direct voltage	100kV	±100kV	±250kV
Current	200A	800A	1200A
Number of valve groups in series per station	Two	Two	Four
Voltage per valve group	50kV	100kV	125kV
Number of anodes per valve	Two	Four	Four
Current per anode	100A	200A	300A
Reactive power supply	Synchronous condenser	Capacitors	Synchronous condenser and capacitors
A.C. supply voltage	Västervik 130kV Ygne 30kV	Boulogne 225kV Lydd 275kV	Penmore 16kV Haywards 110kV
Overhead line	—	—	Approximately 360 miles (580km)
Cable	60 miles (100km) Cable for one pole only Earth return	Approximately 40 miles (64km) of cable per pole Neutral earthed in one station	Approximately 26 miles (40km) of cable per pole Neutral earthed in both stations
Transmission operating at constant	Current or frequency	Power	Power
Supervision	Västervik remote controlled from Ygne	Both stations staffed	Both stations staffed
Power flow reversal	Manual with open circuit	Automatic, instantaneous by changing power control position export-import	May be added in the future

the random conditions that exist in the large evacuated envelope of the valve proper and thus, to minimise the effects of " back-fires." Much of the development work has been concentrated on the anode and multi-grid assembly. The present design, evolved from the original A.S.E.A. patent of 1929 is similar in principle to that of the valves installed at Gotland which, it may be recalled, was the first commercial direct current power transmission scheme in the world.

Each valve has four anodes mounted in a row on a cylindrical steel tank containing the cathode in the form of a mercury pool. A current divider housed in a rectangular enclosure is mounted above each valve to equalise the share of the total current carried by each anode. The full load current is 200A per anode, or 800A per valve. Each

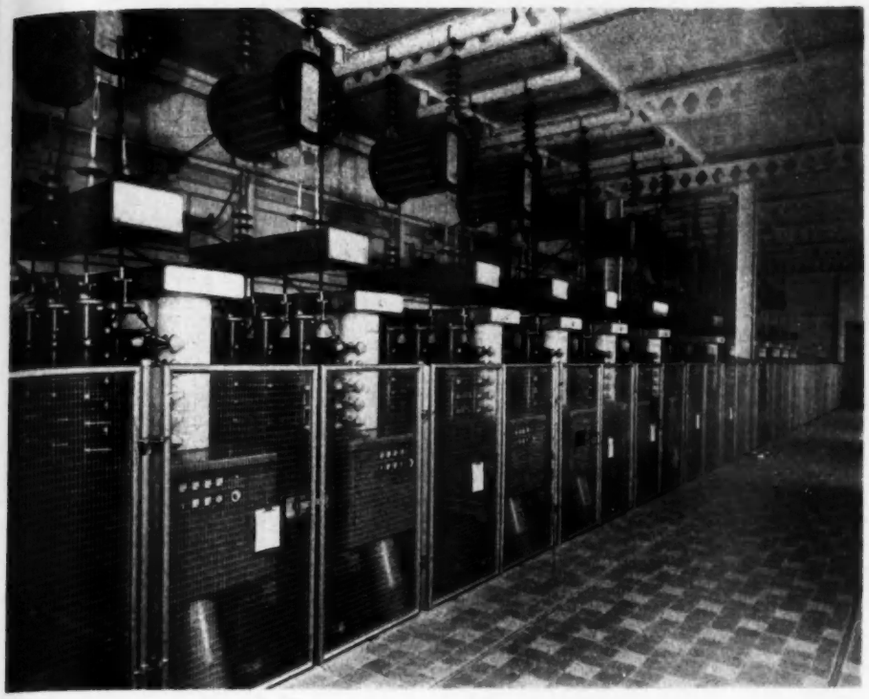


Fig. 2—Valve hall at Lydd, housing two groups, each of six valves, with an additional by-pass valve ; each valve has a rating of 100kV, 800A (200A per anode)

anode is enclosed in a porcelain cylinder inside which a number of grids are spaced between the anode at the top and the cathode at the bottom. The function of these grids (except the bottom one) is to distribute the anode voltage over the whole length of the anode cylinder and this distribution is obtained by connecting the grids to a network consisting of capacitive-resistive voltage dividers. The bottom grid is the control grid proper. It determines the magnitude and direction of the power flow in the d.c. cable link.

A complete valve is shown in Fig. 4. Each of the lighter-coloured cylinders contains an anode. The arrangement of the potential divide network can also be seen. Spark gaps are included in the voltage grading network to relieve a severe over-voltage on any of the grids.

Because the anode must be kept at a constant temperature the porcelain shell of each anode is included in an air cooling and heating system, each valve being equipped with a fan and heating resistors. The valve tank and cathode are also air cooled with air drawn through insulating ducts from a ventilating plant in a basement. The potential of the tank is 100kV above earth and the tank is insulated from the floor by tubes of epoxy-resin-bonded glass fibre which serve as ducts for the cooling air. Auxiliary apparatus, including the excitation and grid biasing equipment, low-pressure vacuum pump and protective devices, are also enclosed in the valve tank housing. On the front of the tank (Figs. 2 and 4) there are also separate ammeters to indicate the current carried by each anode ; the lower row of meters indicate temperature and vacuum.

Outdoor Equipment in Converter Station

Reactive power required by the mercury-arc converters is supplied by banks of capacitors installed on the a.c. side of the converter station. They are associated with special filters to prevent the operation of the converters from causing interference. Two kinds of interference must be dealt with. In the first, harmonics transmitted into the a.c. system could cause overheating of consumers equipment in the system, this kind of interference is suppressed by filter equipment (16, 26 Fig. 1) at the converter station. Secondly high-frequency ripple in the d.c. system would cause interference with broadcast and communications systems. Such interference is suppressed by d.c. filters and by the incorporation of a metallic screen in the fabric of the building. The resistors and capacitors in the valve damping circuit are installed in the star-shaped equipments (one per pole of the d.c. circuit) which can be seen to the right of Fig. 5.

One point of difference between the British and French converter stations is in the method of connection of the capacitor banks for supplying reactive power. At Lydd these capacitors (26, Fig. 1) are supplied from the tertiary windings of the converter transformers because of the need for the transformer reactance to augment the a.c. system reactance in obtaining maximum effect from

Fig. 3—(Below) Valve hall at Lydd. On the left is the high-voltage busbar system

Fig. 4—(Right) Two of the four-anode valves under test in the preparation hall at Lydd. The grid voltage grading network and the spark gaps can be seen

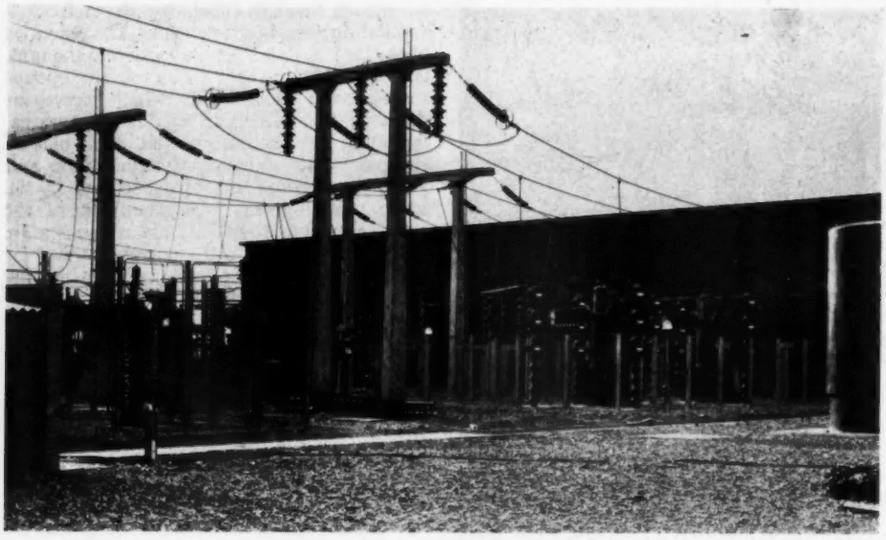


Fig. 5—D.C. substation at Lydd with the valve hall building in the background. On the right are the components making up the damping circuit for the valves; the two star-shaped equipments, one connected to each of the two d.c. poles, include resistors and capacitors

the capacitors. Auxiliary power for this converter station is also taken from the tertiary winding. At Echingen the system reactance is adequate and the capacitors are, therefore, connected to the high-voltage windings of the transformers (10, Fig. 1).

Adjoining the valve hall is a building containing the control room as well as the 11kV switchgear for standby supplies from the Area Board, auxiliary switchgear, metering and telecommunications equipment, batteries and battery chargers.

The control room commands a clear view of the whole site and contains a central control desk (Fig. 6) for the converter plant; it also houses all the relay equipment, a control panel for the 275kV switchgear and control panels for the ventilation plant and for the 11kV and auxiliary switchgear.

Electrical impulses are transmitted to the grids of the valves to control the flow of power in either direction and to protect the system against the effects of fault currents. These control pulses are sent out by electronic equipment.

The system is so designed that either of the two converter stations can control the other, the "leading" station being decided, for a given period by mutual arrangement. Usually the operating programme is drawn up in advance, the timing and magnitude of the flows of power blocks being agreed by the British and French system control centres. When we visited the Lydd converter station last week the d.c. link was being operated on a prearranged weekly schedule but this regime can be varied as required. At any given time the amount of the programmed power transfer is set by a hand regulator and dial on the control desk (Fig. 6) at the leading station. The magnitude and direction of power flow having been set, the control of this is automatic without any need for the transmission of signals between the two ends of the d.c. link except when the loading has to be changed.

Communication is maintained by rented Post Office lines between Thames South Grid Control Centre, and Central Control, Lille and Echingen. Thus duty engineers can see the state of the link and communicate directly with each other. At a later stage, control of Lydd substation will be transferred to Dungeness nuclear power station which is now under construction.

The procedure for changing and reversing power flow was demonstrated during our recent visit to Lydd. At the time the British system was taking an import of 80MW. Reversal of power flow to give an export of 80MW from Britain to France was then carried out at about 3.30 p.m. The change was effected by turning the hand regulator on the central panel of the control desk to transmit the appropriate signals to the valve grids. When the power level (France to Britain) had fallen to between 8MW and zero the valve groups in the British and French converter stations were "blocked" in sequence. At zero power transfer the cable isolator connections were reversed. Between 0 and 8MW (Britain to France) the converters were "unblocked" and then the power flow was increased to 80MW. The whole sequence was carried out automatically through the control grids of the valve groups in the two converter stations and was completed in under two minutes.

In such a transfer the magnitude and direction of the power transmitted are indicated on the power flow control meter on the control desk in each station and the switching sequence is indicated by tell-tale lamps on the mimic diagram on the desk (Fig. 6).

In the sequence described above the cable connections are reversed at the point of zero power flow to maintain the polarity of the d.c. cables after the subsequent reversal of power; this precaution is thought to be desirable for the cables. If reversal of cable polarity is acceptable, as in an emergency, reversal of power flow could be completed in about three seconds.

Maintenance

Valve tanks and anodes are transported to site separately and assembled in special rooms adjoining the main hall in the valve building. These rooms include an assembly room where external parts can be fitted on a new valve or external repairs can be done on a valve. Work on the inside of a valve is done in a separate workshop where "surgically clean" conditions are maintained.

After being assembled each valve must be degassed before going into service. In the degassing process the valve is run with high current and low voltage while it is being continuously evacuated. Equipments for degassing three valves are installed in the degassing room. In the main hall itself six valves can be temporarily degassed.

Transformers

The two transformers which connect the convertors to the Supergrid at Lydd each have three windings. One winding, connected to the 275kV Supergrid, is star-connected and is provided with tappings on a separate winding at the neutral end covering a range of plus and minus 15 per cent in eighteen steps. The tappings are brought out to an on-load tap changer, with high-speed resistor transition, arranged for automatic control. This winding is rated for 95MVA. The next winding is also rated for 95MVA and this feeds the anodes of the valves at 83·6kV. On one of the transformers the anode winding is star connected and on the other delta connected, to produce a six-phase supply to the two valve groups. Finally, each transformer has a 65MVA delta-connected winding for supplying at 33kV a capacitor battery which provides reactive power for the commutation of the convertors. This winding also provides the main auxiliary supply for the station.

The innermost winding is a multi-start coil consisting of the regulating tappings

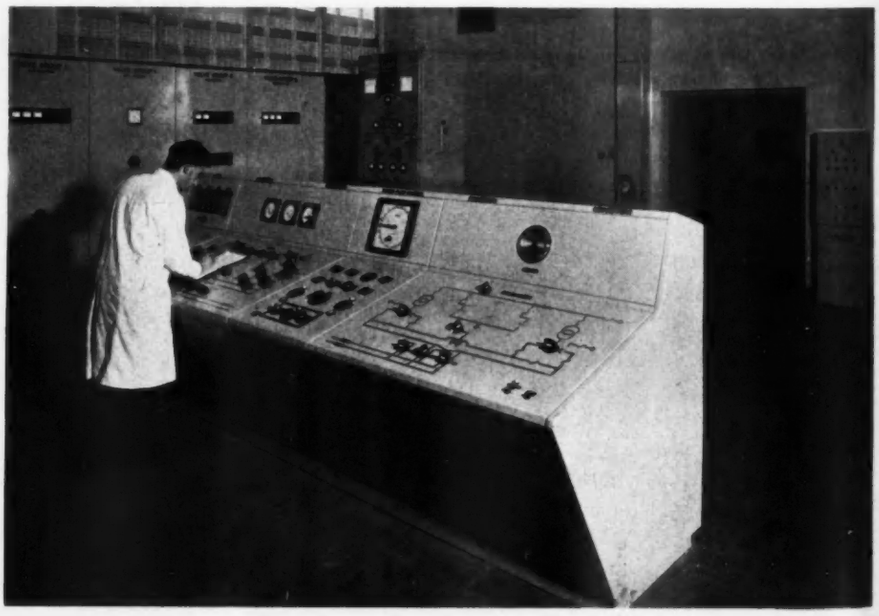


Fig. 6—Control desk at Lydd

associated with the 275kV main winding and these tapping turns are so arranged that magnetic balance is maintained irrespective of the number of tapping turns in use at any time.

Next, outwards from the core is the main 275kV winding. It is unusual to have a winding for so high a voltage as an inner winding but this arrangement is dictated by impedance requirements associated with the convertor plant. A considerable increase in the overall dimensions results from the position of this 275kV winding due to the large clearances required on either side of the coils. Outside the 275kV winding is the 33kV, 65MVA delta-connected winding for supplying the capacitor battery. The outer winding is the anode winding with turns corresponding to a voltage of 83·6kV but insulated to 132kV class. It has an outside diameter of 7ft 8½in. The core is of three-limb construction, built from cold reduced oriented sheet steel and has a weight of 89 tons (active material).

The tanks are shaped to follow closely the contour of the three-phase windings of the transformer, the walls being of cylindrical sections with virtually no flat surfaces. The leakage flux of the transformers is about 26 per cent and to control this leakage flux and avoid excessive losses in magnetic parts, such as core clamps and tank, a special method of shielding these parts is being used. This consists of cladding the main coil supports with copper and fitting an aluminium lining inside the main tank (see THE ENGINEER, October 21, 1960, page 682).

CABLES

The cables and the laying operation have been described in our issue of June 2, 1961.

Briefly, the cable route is about 34 miles long, from Le Portel to Dungeness Point. Starting from the converter station at Lydd there is a length of about 4 miles of land cable which is joined to the submarine lengths, both of British manufacture up to mid-Channel, where they are joined to the French-made cables. The British part of the submarine cable (two 28,000 yard lengths) has a cross-section of 0·525 square inch and is made of stranded copper with an electrostatic screen, surrounded by solid lapped paper insulation, followed by screening, lead-alloy sheath, vulcanised rubber tapes and armouring by a single layer of 0·232in galvanised steel wires, bedded and served overall. To avoid damage to the cable if it has to be lifted for repairs anti-twist tapes were applied under the anti-corrosion rubber tapes. The design stress is about 150kV per cent at ambient temperature.

Because of differences in heat dissipation the land cables are larger than the submerged cables. On the English side the land cables have conductor cross-sections of 0·6 square inch in normal loam and 0·925 square inch in areas containing shingle. On the French side of the crossing the land cables are of 605mm (0·938 square inch) conductor cross-section. On the beach they are armoured; elsewhere they are unarmoured and laid in troughs.

MAIN CONTRACTORS

The main contractors for the cross-Channel power link were as follows:

British end.—Cables: British Insulated Callender's Cables Ltd., Associated Electrical Industries (Woolwich) Ltd. Converter equipment: A.S.E.A., Sweden. Rectifier transformers: Fuller Electric Ltd. 275kV outdoor substation and outdoor switchgear for converter plant: A. Reyrolle and Co. Ltd. Civil engineering works: Richard Costain Ltd.

French end.—Cables: Trefileries et Laminoirs du Havre, Société Alsacienne de Constructions Mécaniques, Forges et Ateliers de Constructions Electriques de Jeumont, and Câbles de Lyon. A.C. equipment at 225kV and 90kV substations: Société Générale de Travaux Electriques. Converter equipment: A.S.E.A., Sweden. Main transformers at converter substation: Alsthom.

Books just published

Moment Distribution, a Rapid Method of Analysis for Rigid-jointed Structures

363 *pages. Diagrams.*
Publisher: E. and F. N. Spon Ltd.
by EDGAR LIGHTFOOT, M.Sc.(Eng.), Ph.D., M.I.Struct.E., A.M.I.C.E.
Price 67*s.* 6*d.*

The author is Reader in Civil Engineering at the University of Leeds and the book is intended for degree and post-graduate students as well as practising engineers. The basic theory of moment distribution is recapitulated, then the application of both basic and newly-developed theory to many different types of structure is demonstrated. There is an index and many lists of references.
[Reply Card No. 1349]

A Power Policy for Britain

125 *pages. Illustrations.*
Publisher: Ernest Benn Ltd.
by K. L. STRETCH.
Price 18*s.* 6*d.*

In this book the author examines the factors which affect the supply of energy from different sources to homes and industries in the British Isles. He suggests a pattern of development deploying capital and man-power to produce better production facilities; research into long-term possibilities; and reforms necessary to achieve these ends. Chapter headings are sources, markets, policy, benefits, reforms necessary, and further reflections. There is an index.
[Reply Card No. 1355]

Analysis of Statically-Indeterminate Frameworks

158 *pages. Diagrams.*
Publisher: Longmans, Green and Co. Ltd.
by T. M. CHARLTON, M.A., B.Sc.(Eng.), A.M.I.Mech.E.
Price 30*s.*

The reader of this book requires a thorough knowledge of elementary statics, including analysis of statically determinate frameworks, but no prior knowledge of the theory of statically-indeterminate frameworks is assumed. The author, a lecturer in engineering at Cambridge, who has been a practising engineer, seeks to present a new course in the elements of the subject in which it is presented in a logical sequence. He utilises stiffness and flexibility coefficients to analyse pin-jointed frames. Beam systems and rigidly-jointed frames are discussed, as are the concept of the elastic centre and the principles of virtual work. The book is not intended to be exhaustive and the theory of bending of elastic beams is omitted as well as the plastic theory of structures. There is an index and a brief bibliography.
[Reply Card No. 1363]

The Consulting Engineer

258 *pages.*
Publisher: John Wiley and Sons Inc.
by C. MAXWELL STANLEY.
Price 48*s.*

This book is concerned with the conduct and running of a consulting engineer's practice, rather than with the technical and engineering problems of construction and design. The book is divided into two sections, the first of which deals with professional relations with clients, other consultants and the public. Part two deals with the internal problems of a consulting practice, and discusses organisation, personnel, plant facilities, procedure and management situations. There are three appendices about sample contracts, description of grades of consultant engineers and a suggested classification of accounts. There is also an index.
[Reply Card No. 1377]

Elements of Nuclear Engineering

213 *pages. Illustrations. Diagrams. Chart.*
Publisher: John Wiley and Sons Inc.
by GLENN MURPHY, M.S., Ph.D.
Price 60*s.*

The object of this book is to survey the field of nuclear engineering and to indicate its scope, potentialities and limitations. It gives a general picture of radiation, fission, fusion and other nuclear transformations, with indications as to how these may be exploited in industrial and engineering applications. Sections are included on the engineer and nuclear energy, nuclei and nuclear reactions, radiation, introductory reactor theory, engineering considerations of nuclear power, radiation detection, shielding and radiation effects and industrial effects of radioisotopes. Appendices consist of a selected list of radioisotopes, a glossary of terms, a folding wallchart of nuclides and an index.
[Reply Card No. 1379]

Hydraulic Fluids and Engineering Applications

190 *pages. Diagrams.*
Publisher: The Trade and Technical Press Ltd.
by R. H. WARRING.
Price 35*s.*

This book is concerned with the properties and applications of fluids to engineering hydraulics or power transmission, with particular reference to the performance of real fluids conducted in pipes or tubes. The first chapters deal with fluid parameters and mathematical solutions establishing the performance of both ideal and real fluids. The remainder of the book deals specifically with individual fluids, their requirements and detailed properties, and associated system performance.
[Reply Card No. 1401]

Analogue Computation, Techniques and Components

271 *pages. Diagrams.*
Publisher: Heywood and Co. Ltd.
by R. W. WILLIAMS, B.Sc., Ph.D., A.Inst.P.
Price 52*s.*

This book is intended as an introductory survey of the electronic and electro-mechanical analogue field, concentrating on components and techniques rather than on complete computers. It assumes a grasp of light current engineering and a knowledge of simple algebra and calculus. The author, who is a senior engineer at English Electric Aviation Ltd., includes chapters on potentiometers, operational amplifiers, a.c. methods, servomechanisms, trigonometric functions, function generators, multipliers and transistor applications. There is a name and subject index and a list of references at the end of every chapter.
[Reply Card No. 1400]

Mathematical Methods for Technologists

584 *pages. Diagrams.*
Publisher: The English Universities Press Ltd.
by MARGARET STRAIN, M.A.
Price 50*s.*

This book, written by Miss Strain and five of her colleagues at the Birmingham College of Advanced Technology, is an attempt to cover in one volume the more essential material required for a Diploma in Technology course in mathematics. There are chapters on limits and their applications, integration, ordinary differential equations, and ordinary and partial differential equations of mathematical physics and engineering, calculus methods, vectors, complex variables, the Laplace transform, matrices, numerical methods, non-linear differential equations and the calculus of variations. There are an index and answers to the exercises in the text.
[Reply Card No. 1403]

400kV Overhead Transmission Line Across the Thames

By H. R. SCHOFIELD, Assoc.I.E.E.,*
W. R. COWLEY, A.M.I.C.E.† and
G. ORAWSKI, B.Sc.(Eng.)Hons.†

The Central Electricity Generating Board's scheme for the reinforcement of the 275kV/400kV supergrid in the South Eastern part of England includes a 400kV crossing of the River Thames to complete the ring around London, to strengthen the connections from the power stations being built on the Thames Estuary into the area south of the River Thames, and to be a link with the e.h.v. direct current submarine cable connection laid across the English Channel. The super-grid transmission system is designed to operate initially at 275kV with facilities for conversion to 400kV with a normal load capacity of 900MVA per circuit.

The 4500ft span over the Thames seen across drainage water from reclaimed mud flats on South Bank. The completed project—October 1961

THIS scheme involved a double-circuit overhead transmission line crossing of the River Thames at St. Clements or Fiddler's Reach between a point adjacent to the 1300MW West Thurrock generating station on the north side, and Swanscombe on the south side. The river, which carries a large volume of traffic at this new crossing point, is 4100ft wide with a maximum depth of 63ft at maximum high water spring tide, with a rise and fall of 19ft. Eight miles up the river, at Dagenham, is the 132kV high-river crossing installed by the former Callender's Cable and Construction Company in 1932.

The contract for the new crossing was awarded to British Insulated Callender's Construction Company Ltd. and completed in October, 1961.

Although the crossing conforms to the conventional pattern of two high suspension and two shorter anchor towers there are a number of special features, apart from its long span and exceptionally high suspension towers, which distinguish it from others. These features largely centre around the design, size and make-up of the steel-cored aluminium single conductor used for each phase and similar earthwire, and the special conditions under which these conductors were to be installed.

River Navigation Clearances.—The volume of traffic and the size of ships passing at the point of crossing are such that the Port of London Authority stipulated a minimum clearance of 250ft, under all climatic conditions, between the mean high water spring tide level and the lowest conductor. This requirement also applied to the Dagenham crossing and compares with the 135ft clearance provided at the 275kV River Severn crossing completed by J. L. Eve Construction Company in 1960.

Survey.—The initial survey of the crossing was carried out by the consulting engineers for the foundation works, which were the subject of separate contracts. This was twice checked by the main contractors for the overhead line, firstly at the commencement of ground works and secondly following

* Chief transmission project engineer, Central Electricity Generating Board.
† British Insulated Callender's Construction Company Ltd.

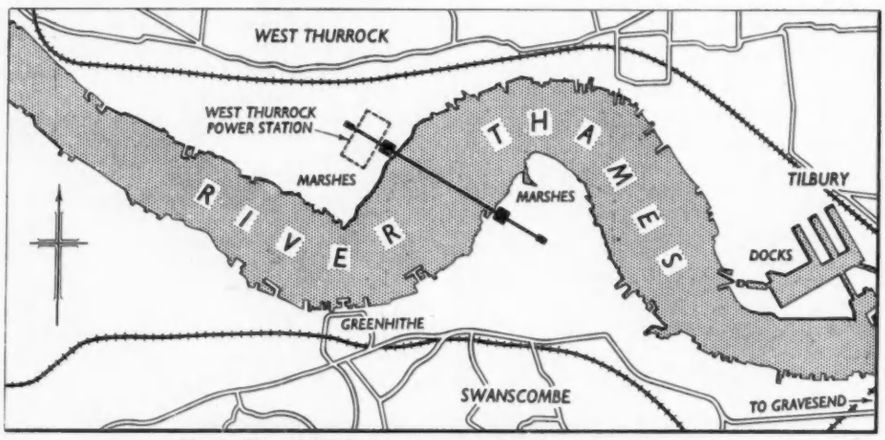


Fig. 1—Site of 400kV line across the Thames at West Thurrock

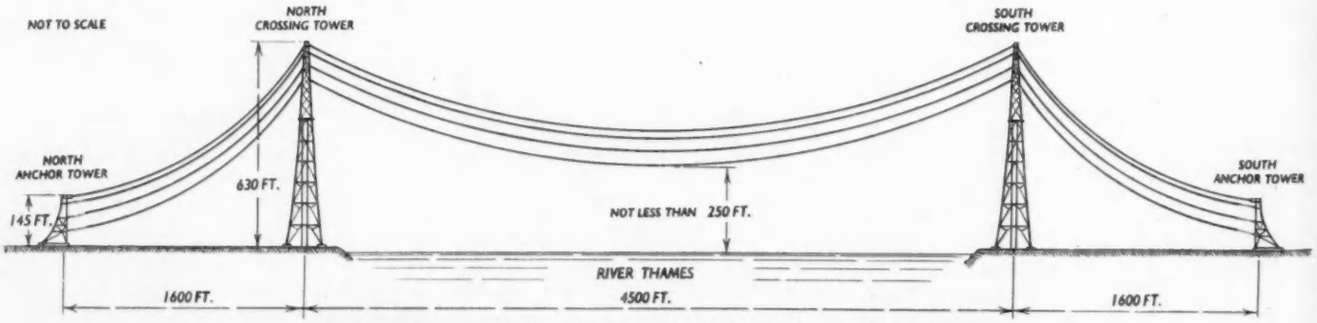
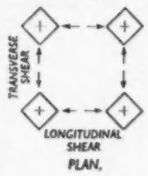
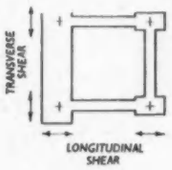


Fig. 2—Profile of the 400kV transmission line across the Thames at West Thurrock

TABLE I—*Particulars of Foundations*

Tower type	Description	Maximum loads, per leg tons	Number of pile	Holding down bolts: Number per leg	Diameter	Length	Tubes diameter	Leg slope to vertical
Crossing	All four legs similar 	Uplift 640 vertical Thrust 1200 vertical Shears 145 longitudinal, 145 transverse	30 per leg	8	3in	11ft 6in	6in	9 deg.—0 min—1 sec across the diagonal
Anchor	2 uplift legs, 2 thrust legs 	Uplift legs: 540 vertical, 400 longitudinal shear, 145 transverse shear	Total 99	8	3¼in	14ft 9in	6in	37 deg.—28 min—35 sec
		Thrust legs: 695 vertical, 20 longitudinal shear, 60 transverse shear		8	1¼in	6ft 6in	4in	Zero

All loads include a factor of safety.

the establishment of permanent markers at each of the four tower sites, when it was established that they are positioned within 3in along line and aligned within ¼in. The accuracy of alignment was achieved by theodolite observations at night with the aid of vertically-mounted fluorescent tubes and v.h.f. radio control.

The consultants took the opportunity of testing the suitability of the "Tellurometer," an electronic device for measuring the route length between anchor towers, which showed an error of 8in by comparison with the conventional survey over the measured distance of 7700ft.

Foundations.—Following site investigations in depth it was decided that the structure foundations should be based on the installation of 60ft long, 17in square pre-cast reinforced concrete piles. The driven lengths are approximately 40ft on the North Bank and 45ft on the South Bank.

Connection between the tower leg bases and the foundations is by high tensile steel holding down bolts grouted into mild steel tubes with a heavy steel grillage at the lower end, the whole being embedded in the pile caps. (Table I and Fig. 3.)

Fig. 3—Holding down bolt assembly for north suspension tower being lowered into pile cap

TOWERS

(*a*) *Loading Conditions.*—The wind load conditions adopted for the design of the structures vary considerably, because of their height and importance, from those specified for normal supergrid line construction. For comparison, the basic loading conditions are set out in Table II. Supplementary conditions covering 45 deg. and longitudinal wind loads were specified for the suspension towers.

For the anchor towers the transverse and vertical loadings were similar to those applicable to the suspension towers. Longitudinal loads allowed were the components of the maximum tensions in the conductors and earthwire at their points of attachment, the effect of incoming lines being taken fully into account. Both suspension and anchor towers were designed for the breakage of any three conductors, line or earth, at full tension in the case of the anchor towers and at a reduced tension of 20,000 lb on the assumption of conductor slip through the insulator saddles of the suspension towers.

Factors of safety, based on the elastic limit or the crippling stress of struts of 2·5, under normal conditions, and 1·5, under broken wire conditions, were specified and had to be maintained with one or two circuits erected. The tops of all towers were largely designed on loads imposed during conductor erection ; the remainder of the tower bodies were not adversely affected by these loads.

In the earlier stages of design an investigation into the possible use of round bars for the suspension tower main legs was made, but was abandoned due to the non-availability of sections of adequate size and quality to permit the welding on of connecting plates. All four towers are, therefore, constructed from rolled steel sections, a very high proportion being high-tensile steel, hot-dip galvanized with bolted connections throughout. The main legs consist of four angles in a cruciform pattern.

(*b*) *Suspension Towers.*—The suspension towers, of equal height, are of a conventional square base "eiffelised" shape, submitted

TABLE II—*Comparison of Basic Tower Loading Conditions*

Description of load		Intermediate tower 400kV lines using twin 0·4 square inch copper equivalent S.C.A. conductors	Crossing towers West Thurrock		
	Wind pressure on full projected area of conductors with ½in radial ice	8 lb/ft² on half sum of adjacent spans	15 lb/ft² on 80 per cent on half sum of adjacent spans		
	Wind pressure on structures	25 lb/ft² on 1⅓ times projected area of one face	Height ft	Pressure lb/ft²	Times* projected area of one face
Transverse			0–150...	25	2
			150–300...	33	2
			300–450 ...	42	1·7
			Above 450	50	1·7
	Wind pressure on insulators	Nil	On full projected area of: strings 30 lb/ft², assembly fittings 50 lb/ft²		
Vertical		Weight of ice covered conductors on twice normal span Self-weight of tower, insulators and other fittings	Vertical components of conductor tensions under most unfavourable conditions Self-weight of tower, insulators and other fittings		
Longitudinal		Nil	Difference in horizontal components of conductor tensions, under most unfavourable conditions		

* Areas to include that of platforms and ladders, &c.

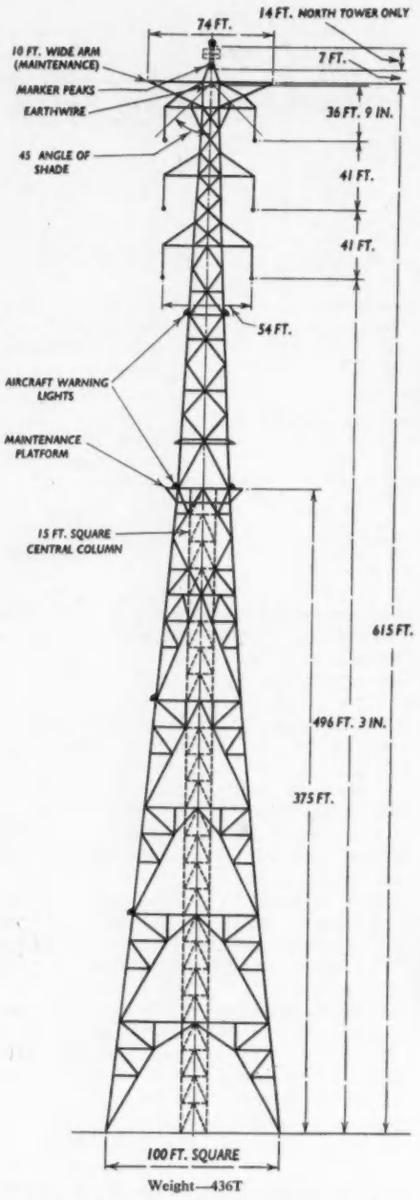


Fig. 4—Main dimensions of suspension tower

to and accepted by the C.E.G.B. after reference to the Royal Fine Arts Commission. The general dimensions are shown on the outline diagram, Fig. 4.

The height of the first six panels up to the 375ft level matches the requirement to provide aircraft warning lights at 125ft intervals. A 15ft square central column extends from ground line to the top of the sixth panel and supports a stairway on its outer faces. It provides a well to enable materials and equipment required during line maintenance to be lifted to the platform which surmounts it. This central column was designed to support the main derrick used to erect the lower part of the structure in the manner described later.

Permanent features of these towers are, maintenance platforms at each crossarm level, winches at the 375ft and 559ft levels, and a top maintenance crossarm at a height of 615ft. Aluminium ladders suspended from tracks on the transverse faces at the highest conductor crossarm are 112ft long. They can be moved and locked in position to permit maintenance on any of the six suspension insulator assemblies.

The South Bank suspension tower is surmounted by a 7ft high marker peak carrying two aircraft warning lights; that on the North Bank has a further 13ft of structure supporting a third lamp and a cylindrical marker. In addition to the lights just mentioned, there are, on both towers, lamps mounted on diagonally opposite legs at the 125ft, 250ft, 375ft and 477ft levels. Access to these is provided by means of catwalks from the main stairway and conventional ladders above 375ft.

The specially-designed tower tops accommodate equipment and additional platforms required for conductor erection.

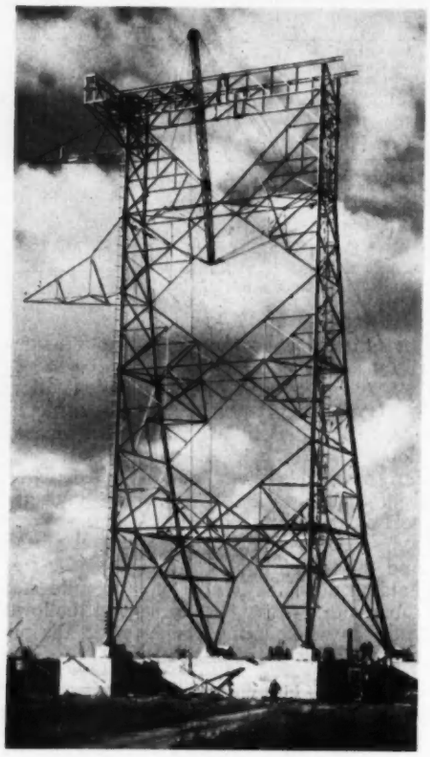


Fig. 5—North anchor tower during erection

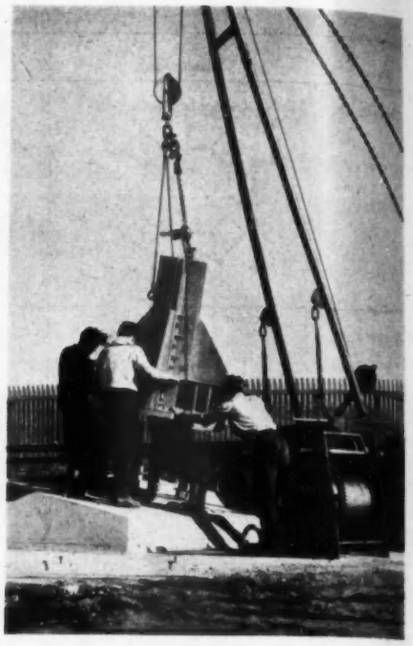


Fig. 6—Suspension tower leg base being lowered into position

(*c*) *Anchor Towers.*—These are both 145ft high, their base dimensions being 54ft transverse and 60ft longitudinal. The front face is vertical and the back face has a variable slope over the first three panels, the top 33ft panel being vertical and 10ft wide (Fig. 5).

Conductor attachments are direct to the main legs at 30ft, 71ft, and 112 ft above the base. The earthwire is terminated at the centre of the top horizontal on the front face. Secondary attachment points are provided above and below each conductor strain

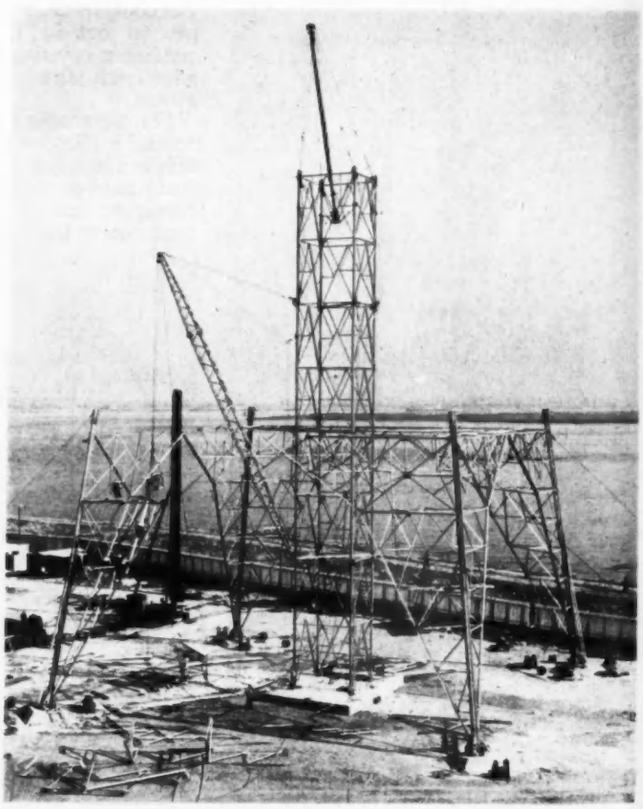


Fig. 7—Erection of bottom panel of north crossing tower showing 80ft derrick in luffing rig

plate and on each side of the earthwire position to permit the use of bridled tackles when sagging and landing conductors and earthwire.

Access to the conductor attachment points, conductor erection platforms, and tower top is by vertical ladders.

Tower Erection

Tower leg bases were accurately levelled and set dimensionally to within $\frac{1}{16}$in. The care necessary during this operation can be gauged from Fig. 6, which shows one of the suspension tower main leg baseplates, weighing just over 2½ tons, being lowered over the holding-down bolt arrangement.

(*i*) *Crossing Towers.*—Following the erection of the first 125ft of the central column, an 80ft derrick in luffing rig was supported from one of its corners (Fig. 7). The first of four corners of the bottom tower panel was then assembled and bolted up, the main leg being held in position by guying to stirrups cast in concrete some 250ft back across the diagonal of the tower. The remainder of the bottom panel was erected in the same manner by moving the derrick from corner to corner of the central column. A further 62ft 6in of central column was then erected and the derrick raised a similar amount. The first five panels were erected in this sequence in a period of three months with a gang strength of ten men, the weight of steel involved being 251 tons per tower. The bottom panel, together with the base-plates, weighs 70 tons, which is equivalent to nearly seven times the weight of a standard suspension tower as used on the twin 0·4 square inch copper equivalent S.C.A. conductor supergrid lines, which form the approach lines to the crossing.

A special method of rigging the 80ft derrick was adopted for the erection of the sixth panel, after which it was converted and used as a floating derrick supported by steel-wire guys and pennants from the tower legs. The remainder of the tower body was erected with this rig.

The combined top conductor and maintenance crossarms, incorporating gussets fabricated from weldable quality high-tensile steel plate, were the most difficult to erect and called for an additional derrick at the 600ft level ; they were assembled section by section, and, when completed, were used to raise the lower conductor crossarms assembled on the ground.

As mentioned, the north crossing tower was sited within the boundaries of the West Thurrock Generating Station, under construction at the same time as the overhead crossing. The noise created by other contractors' continuous pile driving operations would have caused a serious hazard to safety by interference with audible signals between steel erectors and winch operators during tower erection, had it not been possible to arrange for this work to be carried on outside normal working hours.

(*ii*) *Anchor Towers.*—The erection of these structures, 145ft high, did not present any special problems and was mainly carried out when adverse weather conditions prevented work on the high crossing towers.

Line Materials

While steel erection was taking place, the design, manufacture and testing of the remaining line materials was proceeding. A brief description of the most important items follows :

1. *Insulators.*—Both the suspension and tension assemblies, suitable for operation at 400kV, consist of multiple strings of porcelain cap-and-pin-type discs with conventional ball and socket fittings. The strings, connected in parallel, are arranged in pairs with a lever balancing system to ensure that the total conductor load is evenly distributed between the strings, and that in the event of breakage no damage will occur to the remaining insulator discs or the conductor. Maintenance equipment is provided to permit the replacement of individual discs as necessary. Arcing rings are fitted at the line and earth ends of all assemblies, the gap between them being adjustable to suit the initial and final line voltages.

The composition, electrical and mechanical design characteristics, are given in Table III, and electrical test results in Table IV.

The saddle fitted at the bottom of the suspension insulators (Fig. 8) on the high crossing tower is designed to permit the conductor to slip freely through it in the event of breakage and to provide a bearing surface over a minimum distance of 7ft, assuming a 40 deg. change in direction of the conductor. The saddle is 8ft 2in long and has a groove 3$\frac{3}{4}$in wide sufficient to accommodate the conductor when protected by armour rods.

2. *Armour Rods.*—A set of these comprises sixteen 20ft long aluminium rods annealed to a tensile value between 13,000 lb and 15,000 lb per square inch with a maximum diameter of 0·508in tapered to 0·169in at each end over a distance of 50in. The length of a set of rods, after twisting, is approximately 18ft between the corona bells clamped at each end.

3. *Vibration Dampers.*—Dampers of the Stockbridge type using 18½ lb weights were installed in varying arrangements at the time of conductor erection. On the basis of data obtained by the application of vibration recorders, they have since been re-arranged in a uniform pattern, there being six at each end of the crossing span and four at each end of the anchor spans, all spaced at 3ft 6in centres, which leaves a gap of 1in between adjacent dampers.

Conductors

Although the C.E.G.B. have adopted a twin-conductor arrangement on supergrid lines, they specified a single conductor per phase on this crossing—a decision largely influenced by the high mechanical strength necessary to keep the sag within reasonable limits in the 4500ft crossing span. The use of twin conductors would have appreciably increased the tower loadings and had an unfavourable influence on the overall cost of the crossing.

The six conductors and similar earthwire are of steel-cored aluminium construction with a smooth exterior adopted to reduce aerodynamic effects. They comprise a central 0·132in diameter steel wire overlaid with ninety 0·123in diameter preformed steel wires, all galvanised and of 120 tons per square inch tensile strength, in five layers. There are seventy-four aluminium round

Table III—*Particulars of Insulators (as specification)*

	Suspension Assembly	Tension Assembly
Type of unit	Anti-fog	Standard
Outside diameter of unit, in	14	12¾
Electrostatic capacity of unit mmfd	55	55
Minimum protected leakage path of unit, in	12⅞	10¼
Overall leakage path of unit, in	21	16¼
Distance between centres of unit, in	6¾	7½
Number of units in string	20	20
Number of strings in assembly	6	8
Length of string	11ft 3in	12ft 6in
Overall length of assembly	21ft 10 $\frac{1}{16}$in	24ft 6¼in
Minimum elastic limit of assembly, lb	180,000	240,000
Minimum breaking load of assembly, lb	210,000	336,000
Weight of complete assembly, lb	6,600	7,090
Gap between arcing rings :		
275kV, in	84	84
400kV, in	100	100
Dry flashover of insulator string, kV	750	750
Wet flashover of insulator string, kV	600	600

Table IV—*Electrical Test Results on Insulators*

A. Flashover Tests

These were made generally in accordance with B.S. 137 : 1941.
Results corrected to standard atmospheric condition were as follows :

Assembly	Gap between rings in	50 per cent dry impulse flashover voltage kV peak		Power frequency dry flashover voltage kV r.m.s.	Power frequency wet flashover voltage kV r.m.s.	
		Positive	Negative		Mean of first five readings	Mean of last five readings
Suspension	84	1,280	1,280	770	610	560
Suspension	100	1,515	1,545	865	675	640
Tension	84	1,305	1,260	685	—	—
Tension	99	1,535	1,510	805	—	—

All dry flashovers on the suspension assembly took place between rings clear of insulators. The majority of wet flashovers were not clear of insulators. On tension assembly flashovers clear of insulators were in the minority.

B. Corona Tests

Visual observations were made of inception and extinction corona voltages, at power frequency, when both tension and suspension sets achieved values of over 300kV (corrected for air density but not humidity), the critical part of the fitting being the joints on the h.v. guard ring.

In addition a sustained voltage of 270kV r.m.s. corresponding to 265kV at standard air density was applied to the tension sets with no discharges, and a voltage of 445kV was applied for 3½ minutes during which there was no corona on the insulators or earthed fittings, but corona on the four joints of the h.v. ring and on the radius of the supporting arms.

A sustained voltage of 270kV was applied to the suspension set, with no corona on rings or saddles.

At 305kV there was slight corona on the armour rods.

At 445kV there was no corona on the porcelain insulator units.

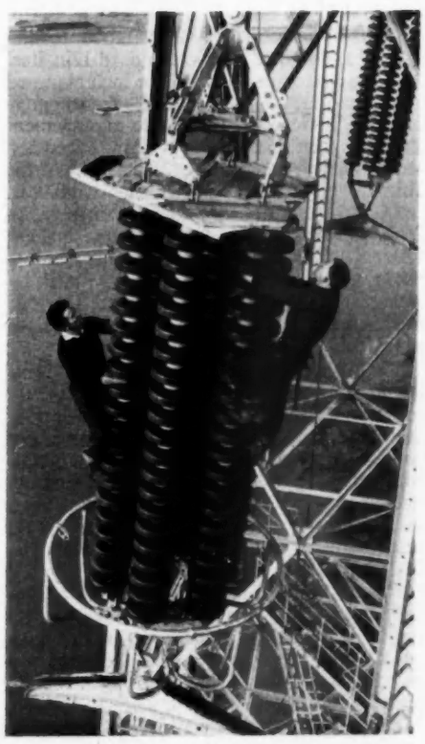
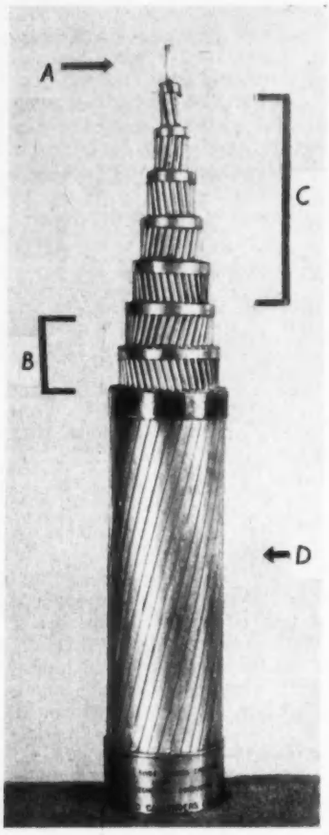


Fig. 8—Erection of suspension insulators on south crossing tower

wires of 0·133in diameter arranged in two layers and a final layer of thirty-six 0·160in deep aluminium wedge segments. The complete conductor is greased throughout but with a dry exterior.

Other smooth-body types investigated were : a similar construction with shallower wedge segments, a locked coil construction and a conventional round wire construction with a p.v.c. covering.



A—One galvanised steel wire 0·132in diameter.
B—Seventy-four aluminium wires 0·133in diameter
C—Ninety galvanised steel wires 0·123in diameter.
D—Thirty-six wedge-segmental aluminium wires 0·0266 square inches cross section.

Fig. 9—Stepped sample showing make up of conductor for Thames crossing

TABLE V—*Conductor Characteristics*

Where applicable, characteristics shown below were calculated in accordance with B.S. 215 ; Part 2, 1956.

Nominal copper equivalent area, square inch...	1·18
Calculated maximum resistance at 20°C per 1000 yard, ohms	0·0207
Stranding :	
Steel :	
Centre wire	1/0·132in
First layer	6/0·123in
Second layer	12/0·123in
Third layer	18/0·123in
Fourth layer	24/0·123in
Fifth layer	30/0·123in
Aluminium :	
First layer	34/0·133in
Second layer	40/0·133in
Third layer (segments)	36/0·160in deep
Overall diameter of conductor, in	2·214
Sectional area of steel core, square inches ...	1·083
Sectional area of aluminium round wires, square inches	1·028
Sectional area of aluminium segmental wires, square inches	0·958
Total area of conductor (for mechanical purposes), square inches	3·069
Weight of conductor (including grease) per 1000 yards, lb	18,660
Breaking load of conductor, lb...	291,000
Modulus of elasticity, lb per square inch ...	$16{\cdot}45\times10^6$
Coefficient of linear expansion, per deg. Fah....	$8{\cdot}85\times10^{-6}$

The following values were obtained by test :

Modulus of elasticity, lb per square inch ...	$13{\cdot}68\times10^6$
Coefficient of linear expansion	$8{\cdot}70\times10^{-6}$
Assumed maximum load current, amp ...	1,550

A final decision was reached, after handling trials, using both the adopted segmental and locked-coil types, during which the basic erection conditions were simulated. The design, which had to comply with B.S. 215 where applicable, was carried out in close collaboration with the C.E.G.B. The make-up is shown in Fig. 9, and the main characteristics in a Table.

A special provision of this contract was a requirement for compression-type dead-ends to be fitted in the factory, because in view of the high tension involved to maintain the conductors clear of water and ground during their erection, site fitting could not be contemplated. This called for very accurate sag, tension and length calculations by the pure catenary method. Where it was necessary to use the equivalent span concept, the actual distances between the points of conductor support were used instead of the horizontal span lengths.

The basic condition for conductor sagging was a specified tangential tension at 62 deg. Fah. in still air equal to 25 per cent of the ultimate strength of the conductor. The resulting maximum tension assumed to occur with a wind pressure of 12 lb per square foot on the full projected area of a conductor covered with ½in radial thickness of ice at 22 deg. Fah. was 96,700 lb at the highest point on the crossing. The maximum design sag is at 122 deg. Fah. in still air.

During conductor sag and tension calculations, the electronic computer installed at the Research Laboratories of B.I.C.C. was extensively used. The parameters adopted made allowances for the swing of suspension insulator assemblies, the length of suspension saddles and the length and weight of the tension insulator assemblies.

Modulus of elasticity tests on the steel core and complete conductor were carried out at the National Coal Board Laboratories at Bretby, where facilities exist to test wire ropes with a maximum length of 40ft up to a load of 400 tons. The method adopted was to fit dead-end clamps to each end of a length of conductor which was then placed in the testing machine and packed up level with timber, whilst a purely nominal tension was applied and a gauge length of 400in established.

Suitable telescopes were clamped to the test bed and sighted on two standard 12in steel rules graduated in 100ths of an inch clamped to the conductor at each end of the gauge length. There was a duplicate arrangement on the opposite side of the machine. Tension was steadily applied up to 25 per cent of the ultimate design strength of the conductor, i.e. 72,500 lb and extension readings taken at 3 ton increments at all four stations. Thereafter, tension was held and readings taken at fifteen minute intervals until increases in extension were negligible. The load was then slowly reduced to zero, observations again being made at 3-ton intervals.

The above procedure was repeated for a tension equivalent to 33⅓ per cent of the conductor strength. From plotted results the initial modulus of the steel core and complete conductor were determined, together with an estimate of the amount of inelastic stretch to be expected in service. These results were of paramount importance for the calculation of the conductor length and for the preparation of erection charts.

After allowing for inelastic stretch, tension insulators and sag adjuster linkages, the final unstressed length of each of the seven conductors and two spare lengths was calculated to be 7754ft between dead-end eyes.

A manufacturing tolerance of ±1ft was accepted, and to achieve this degree of accuracy a ⅜in diameter steel conduit was set up, on concrete supports, over an ordnance-survey-checked base line, 230ft long, in the factory. The centre 0·132in diameter steel wire of each conductor was measured by threading it through the tube and marking by file-cut at the first and last positions and by adhesive tape at intermediate points, all necessary allowances being made to correct the lengths to 60 deg. Fah. and no tension. The overall average tension required to pull the wire through the tube was 2½ lb giving an extension of 0·6in on the 7844ft measured.

The conductors were conveyed to site on steel-reinforced wooden drums, 12ft 10in overall diameter and 6ft 5in wide, having a total weight of 26 tons. The dead-end clamps were stored in a special compartment formed by the introduction of a dummy flange. On site, the drums were unloaded by backing the low-load trailer between specially-designed stands incorporating band brakes and raised by hydraulic jacks. The rear four-wheeled axle of the trailer was then removed and its platform lowered to the ground, and the vehicle towed out. This method had to be used due to lack of lifting facilities on site and also to avoid rolling the full drums.

Dead End Clamps.—These were designed to avoid slip, damage, or failure of the conductor at a load less than 95 per cent of its ultimate strength. Tests to prove the clamps were also carried out at the National Coal Board Laboratory.

The clamps are of a conventional compression type requiring a special 200 ton compressor for their fitting to the conductor. The steel sleeve is a little over 3in diameter with a compression length of 21in. The aluminium sleeve is 4 1/16in outside diameter and 56in long before compressing at both ends. The overall length of the clamp after fitting is 5ft 6in and it has a weight of approximately 130 lb. To ensure electrical continuity, twin jumpers are used, and consequently the jumper lug is of sufficient dimensions to accommodate two jumper terminals.

ERECTION OF CONDUCTORS

A further special provision of the contract was a stipulation that each of the six conductors and similar earthwire was to be erected without touching either the ground or the water. The attachment of clamps or other hauling devices to the conductor was prohibited. These requirements led to the consideration of three basic erection methods:

1. By running out under direct tension.
2. By conveyance across the river over special floats keeping the conductors clear of water.
3. By carrying the conductors across the three spans on a previously installed overhead catenary system.

The first method was rejected owing to the serious risk of birdcaging the conductor due to the accumulation of slackness in the outer wires when passing the conductor over suitable sheaves at a tension between 20-25 tons. The second method was unacceptable because it would have meant a closure of the river to shipping for each of the seven wires, much in excess of the permitted maximum of two hours each side of low tide on Sundays only. Whilst the Port of London Authority was prepared to close the river for limited periods only, it was willing to permit conductor running operations at all times, provided that a temporary clearance of 180ft to Mean High Water Spring Tides was maintained.

Several systems under (3) above were investigated and it was ultimately decided to adopt a method similar to that used by the

J. L. Eve Construction Company in erecting the 275kV crossing of the rivers Severn and Wye. Improvements and adaptations to suit the particular conditions of the West Thurrock crossing were made. The equipment and the erection procedure, briefly, was as follows.

A 1¼in diameter full locked coil winding rope—breaking load 88 tons, 8250ft long—was installed as a track rope over carriages running on rail-rack units at the top of all four towers. It was connected by 4×4 tensioning tackles to concrete ground blocks approximately 200ft behind each anchor tower.

Alongside the track rope and 9in above it was installed a $\frac{9}{16}$in diameter steel haulage rope—breaking load 12·6 tons. The length of this haulage rope was 17,000ft, i.e., more than twice that of the three spans, and its ends were connected to 5-ton trailer type winches adjacent to the track rope anchorages.

The erection of the conductor was carried out from the North to the South Bank. When the conductor drum had been mounted on its stand 130ft behind the front face of the anchor tower, the leading end was pulled to the anchor tower top and laid over a quadrant of 6ft radius fitted with a number of 9in diameter rubber lined sheaves. This leading end was fed through to the front of the tower passing over a rubber lined guide roller. A main hauling trolley was attached to the haulage rope by six small bolted type clamps and ran along the track rope on two 9in diameter wheels, two further wheels being fitted on the underside of the trolley to prevent its derailment. The conductor was then connected via a ball-bearing swivel and $\frac{9}{16}$in diameter wire rope tail to a bridle at the rear end of the main trolley.

As the conductor was pulled into the north anchor span, suspenders were introduced at 80ft intervals. Each suspender consisted of : a twin-wheeled carriage running on the track rope and fastened to the haulage rope by means of a quick closing lockable clamp ; a 10ft long aluminium tubular boom, at the bottom of which was a small rubber lined bobbin supporting the conductor. It should be mentioned that suspenders like those just described, except that the conductor bobbin was replaced by a 35 lb weight, had been fitted at 240ft intervals, throughout the system, to ensure that the pull of the haulage rope was always parallel to the track rope.

To support the conductor at the crossing tower tops, cradles carrying two 5ft diameter rubber lined sheaves spaced 26ft apart were suspended from the ends of the maintenance crossarms in line with the track rope by paragon ropes connected to bridles fitted to the cradles (Fig. 10).

When the leading conductor end reached a crossing tower it had to be detached from the main hauling trolley which was removed from the track rope and replaced at the other side of the tower. The conductor end was reconnected with a longer tail to the main trolley in its new position when hauling recommenced at a maximum calculated tension of 4500 lb. By carefully controlling the position of the cradle, it was possible to thread the leading conductor end through its bridles without touching the rubber lined cradle sheaves, on which only the conductor itself was allowed to rest.

The suspenders also had to be removed and refitted upon arrival at the crossing tower. It was possible to do this without interruption to the hauling process. The height of the cradle was adjusted to ensure that suspenders were relieved of conductor load just prior to arrival at the tower and reloaded by the conductor on leaving the tower. During the actual running out, speeds of 30ft to 40ft per minute were maintained.

When the leading conductor end was within 150ft of the south anchor tower it was connected to a holding rope whilst the hauling tail was removed and permanent links and plates connected to the dead-end clamp. On the North Bank the fitting of similar plates was carried out as the trailing dead end was passed through the anchor tower. Non-spin tensioning ropes of 1½in diameter were introduced at both ends and connected by 3×3 tackles to ground blocks behind the anchor towers.

Through these ropes the conductor tension was increased to approximately 44,000 lb when its sag was about the same as that of the track rope. Upon raising the cradles at the suspension towers all suspenders were relieved of conductor load and swung clear. Safety flaps had been fitted over the bottom bobbin of the suspenders to prevent re-entry of the conductor.

The next operation was to lower the conductor to its final level at the towers without encroaching upon the 180ft minimum permitted clearance to water level. To achieve this, the cradles were lowered and conductor tension adjusted through the tensioning ropes. At the suspension towers, fixed length pennants were introduced between the conductor crossarms and the cradle bridle heads to bring the cradles into the final plane of the conductor. The dead-end clamps were lowered down the faces of the anchor towers by means of bridled 3×3 tackles, which were then used to bring the conductor to approximate sag, when its tension was of the order of 34 tons. The conductor was left in this condition while tension insulators, previously assembled in the vertical, with a tubular steel strut inserted, were swung into a horizontal plane and manoeuvred together with sag adjuster linkages into their final line position when they were connected between the towers and the conductor dead-end clamps.

Following a sag check, and adjustment to linkages as necessary, the armour rods were fitted to the conductor between the cradle sheaves and the whole was transferred to the suspension saddles which were then linked to the bottom of the suspension insulator assemblies, previously hung at the conductor crossarm ends.

The cradles and suspenders were then all returned to their starting positions and all other equipment prepared for running out the next conductor.

The order of erection was bottom, middle and top phase of the Eastern circuit ; the equipment was then transferred to a position over the Western circuit which was erected in the same order. The track and haulage ropes, carriages, &c. were then positioned on the centre line of the towers for the running of the earthwire, the procedure being similar to that for the conductors, except that special steps were taken to overcome the complications caused by the restricted space available at the tops of the crossing towers. All conductors being of the same length, a set of linkages was used to compensate for the omission of tension insulators in the earthwire.

Periodic sag checks carried out after erection have shown that the assumptions made at the calculation stage were fully justified.

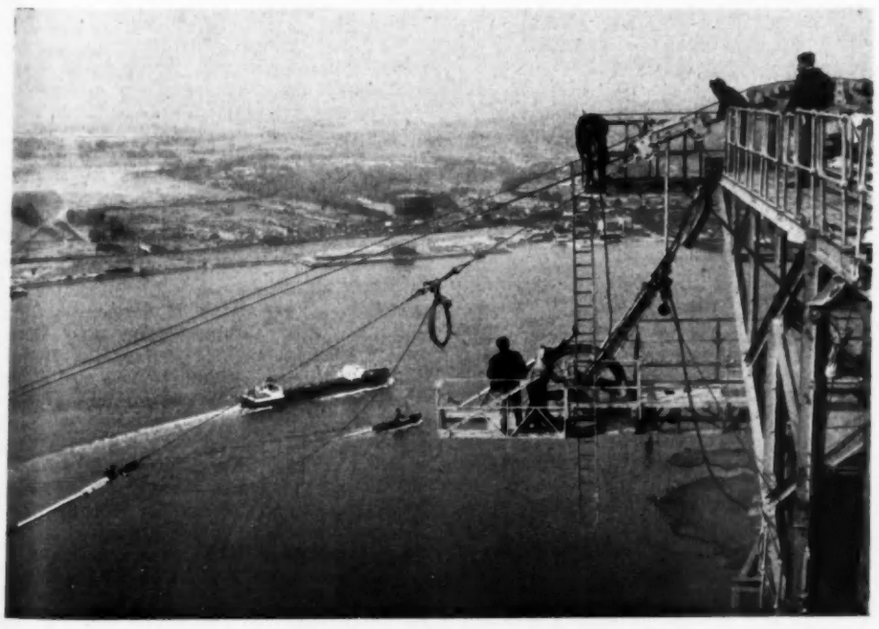
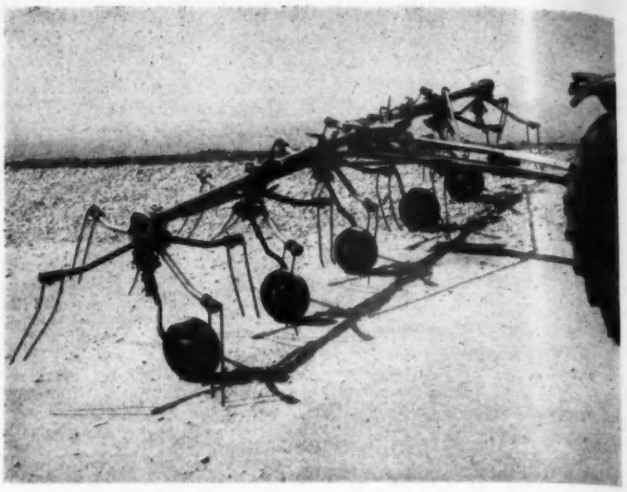


Fig. 10—Top of crossing tower showing conductor cradle suspended on paragon ropes and main hauling trolley arriving at tower

Acknowledgements

The authors wish to express their thanks to the Central Electricity Generating Board and to the main contractors—British Insulated Callender's Construction Company Ltd.—for permission to publish this article and to various organisations for their co-operation during the period of the contract. Services : Port of London Authority. Foundations : consultants, Sir Alexander Gibb and Partners ; contractors, Holloway Brothers Ltd. and Mears Brothers (Contractors) Ltd. Towers : designed by Blaw Knox Ltd., fabricated by Horseley Bridge and Thomas Piggot Ltd.—crossing towers, and Painter Bros. Ltd. (a member of the BICC Group)—anchor towers. Insulators, Bullers Ltd. Conductors, BICC and Rylands Brothers Ltd. Vibration dampers, Electric Transmission Ltd. (a member of the BICC Group). Dead-end assemblies and armour rods, Alcan Industries Ltd. Conductor erection equipment, J. Barnsley and Sons Ltd. Winches, Auto-Mower Engineering Company Ltd. and Henry Sykes Ltd. Ropes, British Ropes Ltd.

Agricultural Machinery at The Royal Smithfield Show



No. II—(*Continued from page* 908, *December* 1, 1961)

The Royal Smithfield Show, which has been held this week at Earls Court, closes this evening. This Show has been presented jointly by the Royal Smithfield Club, the Agricultural Engineer's Association and the Society of Motor Manufacturers and Traders.

IN this issue we conclude our review of some of the new and interesting machinery and equipment which this week has been displayed at the Royal Smithfield Show. This year the show is "live," there being some 1365 live animals participating. Attendance at last year's show dropped because wide-spread foot and mouth disease prevented the exhibition of livestock, but even so, approximately 50,000 people attended to examine the latest mechanical farming equipment and farm tractors.

What is claimed to be the first tractor with an automatic transmission appeared on the stand of David Brown Tractors Ltd. in the shape of the "Autodrive 990." This is basically the same as the existing "990" (see page 882, November 24, 1961) but the reverse train is now included in the "range" (high/low) gearbox and the former three-ratio main gearbox has been replaced by a four-speed gearbox with torque-sustained ("hot") shifts. The ability to change to a higher ratio as speed is gained, and *vice versa*, is of obvious value, and in the past David Brown tractors have used hydrokinetic torque converters which inherently possess such a favourable characteristic. The torque converter, however, has a low efficiency if allowed to run far from its optimum operating condition, and by introducing a complex relationship between vehicle speed and engine speed renders it more difficult to obtain a constant road speed automatically, or to have a "live" power take-off. The new transmission is, therefore, based on a gearbox and the tractor is started from rest by a friction clutch in the ordinary way. The gearbox has four ratios and changes are made by applying oil pressure to multiplate clutches: the oil is supplied from an engine-speed pump and it is arranged that the pressure is a function of speed. The value of the oil pressure then determines which ratio is engaged, i.e. at starting (when the engine speed should be low) first will be engaged, and then as the speed rises successively higher ratios are automatically engaged. Changes down and up

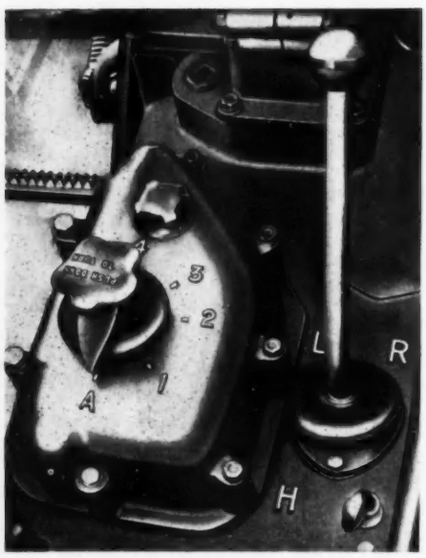


Fig. 6—Transmission controls of a tractor with "Autodrive": left to right, clutch pedal, gear selector (set to "Automatic") and range change lever

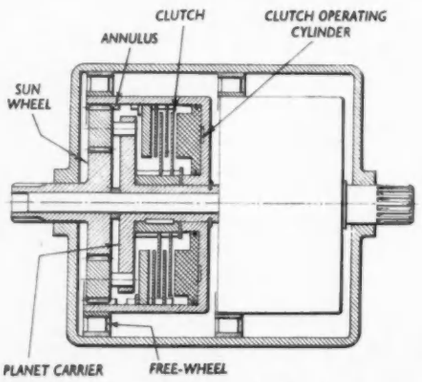


Fig. 7—Diagram showing principle of four-speed epicyclic gearbox

are made at the maximum torque and maximum power speeds of the engine: the fact that the control device is not sensitive to torque means that the engine will not necessarily operate near the optimum efficiency point, but this is less of a penalty with an oil engine than a carburetted engine. So that a desired speed of travelling can be selected on the engine governor, provision is made for the driver to select one ratio which will be held at all speeds, even for starting from rest if the driver selects before starting.

The gearbox, like most transmissions offering "hot" shifts, is based on epicyclic gearing. Full details of the design are not available, but the method of functioning can be indicated with reference to the diagram. The drawing shows one epicyclic cluster in section, and it will be seen that the power goes in to the sun wheel. The planet carrier is driven at a reduced speed, and the additional torque developed by the annulus is transmitted to the casing by a one-way clutch or free-wheel. If now a clutch between the planet carrier and the annulus (or any other two of the three elements) is closed, the entire cluster will rotate, the annulus free-wheeling in the casing.

Clearly, a tractor which can change gear on the move needs fewer rather than more ratios than the orthodox machine, but it was considered that to make only the two-speed wide-ratio change "hot" and automatic would not be satisfactory with the working speed range of the present engine (it is interesting to speculate whether, for an engine with a positive displacement supercharger, this might have been the optimum solution) and, therefore, a second epicyclic cluster has been added: the second cluster has a different ratio from the first, and thus four ratios become available. It will be noted that, since both clusters are supported by free-wheels, the tractor is free to over-run the engine except when the highest ratio is engaged. Since vehicles other than tractors usually have higher transmission efficiencies and less adequate friction brakes, this characteristic may limit its application, although, clearly, hydrokinetic devices could be re-introduced in the form of a retarder. The principle of obtaining four ratios from two epicyclic clusters is, of course, of great age, having been used in a vehicle by Major W. G. Wilson in 1902.

Exhibited by Fahr Products Ltd., is the new K.H.6 "Centipede" tedder shown above. Driven from the tractor power take-off at 540 r.p.m. the tedder is made up of six "stars," each star having four arms and each arm carrying two long spring-loaded tines. In action the stars rotate, causing the tines to raise the crop, turn it, and scatter it to the rear, at the same time clearing the way and ensuring that the land wheels of the tedder do not run over the crop. The angle at which the arms carrying the tines approach the drop can be adjusted by means of a crank. There are three main elements, connected by universal joints, each carrying two stars and two land wheels. The flexibility of the implement allows the land wheels to follow all ground contours, so that if part of the swath is lying in a hollow, the tines will still pick it up.

For transporting the tedder, the two outer elements are turned to the rear and secured by transverse struts, and in this position the centre wheels each side are raised allowing the implement to roll on the other four.

The working width of the K.H.6 is 15ft 9in and at a speed of 7½ m.p.h. its output is claimed to be 10 to 11 acres an hour.

Two new diesel engines are displayed on the stand of F. Perkins Ltd. They are the

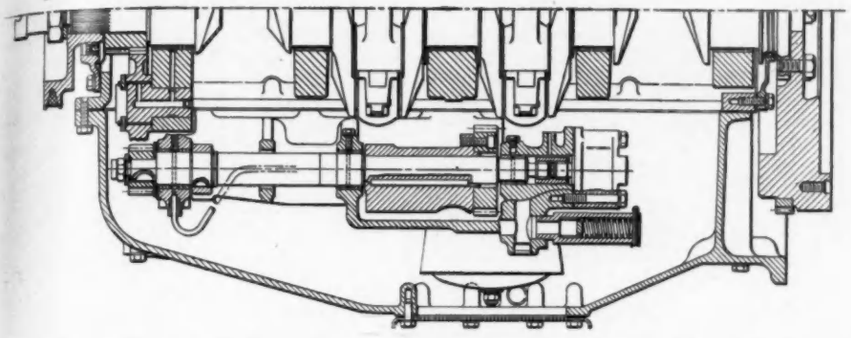


Fig. 8—Longitudinal sectional arrangement of balancer unit on the Perkins 4.300 agricultural diesel engine

74 b.h.p. " 4.300," and the 41 b.h.p. " 4.107 " which was introduced at the Royal Agricultural Show earlier this year and described in our issue of July 7, 1961. The " 4.300 " engine is fitted as original equipment in the new Massey-Ferguson " 400 " combine harvester (THE ENGINEER, October 6, 1961). It is a direct-injection four-cylinder diesel engine, 4·5in bore by 4·75in stroke, with a capacity of 302·2 cubic inches, and a compression ratio of 17·5 : 1. It develops 74 b.h.p. at 2000 r.p.m. and its maximum torque is 228 lb ft at 1000 r.p.m. The combined cylinder block and crankcase is a one-piece high-duty alloy iron casting, the sides of the crankcase extending below the crankshaft centre line to form a stiffening skirt. The rear of the cylinder block casting incorporates a flywheel housing flange, and the whole block has been designed for frameless tractor application. Lugs have been cast integral with the cylinder block at the front end, which with the integral transmission housing at the rear, and the facings at the front and rear of the cast iron lubricating oil pan, form a rigid assembly for the tractor frame.

Of particular interest on the " 4.300 " engine is the balancer unit, the arrangement of which we illustrate in Fig. 8. The unit is fitted enclosed in a frame suspended from the crankcase sump face and is driven from the front end of the crankshaft through an idler gear. Two balance weights, one of which can be seen in the illustration, rotate in opposite directions at twice the speed of the engine, to balance secondary forces. Vibration is cut down, thus making for smoother running and greater operator comfort.

A new grain drying system known as the " Venti Bin," Fig. 9, has been introduced by E. H. Bentall and Co. Ltd. A 1ft 6in square plenum post has been substituted for one of the grain bin's standard corner posts, and the normal corrugations of the bin sides have been converted into hot air ducts, each of which is fed directly from the main plenum chamber. The side ducts are open at the bottom edge so that the warm drying air, supplied from a Woolley heater and fan unit, is directed downwards into the grain. After passing through the grain the damp air escapes into the atmosphere via a perforated metal cylinder set in the centre of the silo. Air-flow along the side ducts is controlled by restrictors to ensure that it is equal at all points along the four walls, thereby allowing even drying throughout the grain mass. According to the manufacturers, a 5 to 6 per cent moisture content reduction in a 25 ton batch of grain takes approximately forty-eight hours. For drying a smaller quantity, a system of baffles can be used to cut off the ducts not required.

Fig. 9—" Venti-Bin " grain drying system

In the manufacture of tractor tyres a balance must be struck between draw-bar pull when working in soil and the life of the tyre tread when the tractor is being used on the road. With its RT32 Fieldmaster tyre introduced eight years ago, the Dunlop Rubber Company Ltd., points out, the tyre inclined rather towards wasteful irregular and rapid wear on the road. The road life of the RT32 was therefore improved. A development of that tyre, and the result of several years' research, is the new RT.40 tractor tyre illustrated in Fig. 10 and exhibited on the Dunlop stand. Width and spacing of the bars has been altered and the rubber volume increased to give a club-like inner-end to each bar, the object being to increase hard-road life without seriously reducing traction. The RT.40 is claimed by the manufacturer to give up to twice the road life of the final version of RT.32, and on heavy soils, draw-bar pull and freedom from slip are equal to those of the RT.32. Under conditions of high torque, the manufacturer states, the sidewalls are more stable than those of the RT.32.

Fig. 10—The Dunlop RT.40 tractor tyre

A bale loader which picks up on the offside of the tractor, in full view of the operator, is shown on the stand of Roadless Traction Ltd. Known as the " Sydelift," it is of lightweight tubular construction and is mounted on the tractor three-point linkage and controlled through the tractor hydraulic system. The bale is picked up from a position to the right and slightly ahead of the tractor rear wheel. As can be seen from our illustration (Fig. 11), the side jaws of the grab are fitted with steel tines which bite into the bale as the jaws close, and automatically release their grip after the boom has been raised up-and-over the rear of the tractor. The bale then rests unattached on a cradle ready for stacking in the trailer following the tractor. The jaws of the grab remain open as the boom is swung down again and close when contact is made with the next bale.

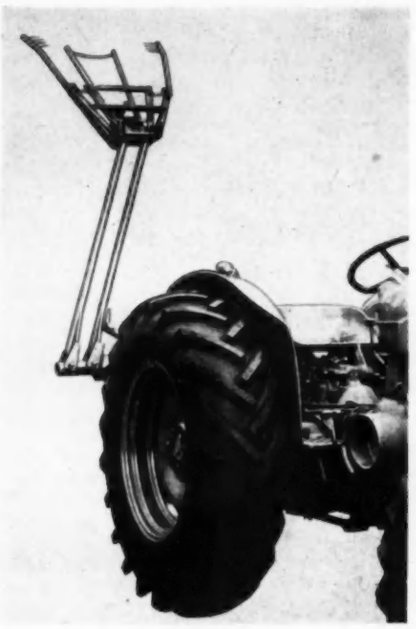


Fig. 11—The " Sydelift " bale loader

A second bale loader, shown in Fig. 12, which has been designed to suit most makes of front end loaders and tractors, is exhibited on the stand of Jeffery Engineering Company Ltd. It will load batches of eight stacked bales at the rate of approximately 400 an hour. The J.E.C. " Perry " bale loader is directed to the bale stack with the attachment lowered to within 4in of ground level. Operation of the hydraulics then causes the jaws of the attachment to grip the base of the stack, which is then raised hydraulically to the required height and placed on the trailer. Release of the jaws is effected by heavy-duty tension springs.

The loader is of welded construction and the main frame and jaws are of 3in by 1½ in channel steel. The jaws are closed by a single-acting 2⅜in bore hydraulic ram and are returned to the open position by springs. The load is kept parallel to the ground by a flexible steel cable and attachment post.

Ransomes Sims and Jefferies Ltd. is showing on its stand three new FR mounted disc harrows. Replacing the old type light

Fig. 12—Front-end bale loader handling eight stacked bales

trailing disc harrow, the HR31-86 which we illustrate in Fig. 13 has a working width of 8ft 6in and is shown in its standard form with twenty-eight 20in discs with scrapers. It is also available with twenty-eight 18in discs and scrapers, whilst a third variant, known as the HR31-76, has a working width of 7ft 6in and twenty-four 18in discs and scrapers. The angle of the gangs is easily adjustable to suit varying soil conditions, and the spacing of the discs at 7in intervals is claimed to break down clods with very little risk of clogging.

The Ford Motor Company Ltd. announces that a differential lock, already standard equipment on the Fordson " Super Major " tractor, will in future be fitted as standard on all agricultural builds of the " Dexta " tractor. It has also announced that both the Fordson " Super Major " and " Dexta " tractors can now be equipped to work two external hydraulic rams independently of each other, which will enable tools such as a fore-end loader and a rear-end buckrake to be mounted simutaneously and operated independently. The new dual auxiliary valve gear is marketed as a parts-kit.

The " Haypacker," a machine which compresses hay into 2in cubes or wafers, is shown on the stand of Massey-Ferguson Ltd. Independently powered, the " Haypacker " is a trailed machine carried on two wheels and the tractor drawbar. Tests are to be carried out to determine handling, storage and feeding qualities of haypacks made of grasses and grass mixtures in the United Kingdom. Manufacturing and marketing rights of the hay wafering machine have been purchased by Massey-Ferguson from The Lundell Manufacturing Company, which will continue to manufacture its own machines in the United States.

Automatic Assembly Machine

Particulars have been released by Vauxhall Motors Ltd. of a twelve-head automatic machine developed for the assembly of shock absorber piston and rod assemblies. This machine was put into service in October, 1959 *and has produced well over* 2,000,000 *assemblies since that date.*

A TWELVE-HEAD automatic assembling machine in service at the works of Vauxhall Motors is capable of assembling nine different classes of piston and rod units for double-acting telescopic shock absorbers at a rate of 600 an hour. During any one cycle thirty units are in process of assembly and for each assembly eleven components are placed on to the threaded end of a shock-absorber piston rod in the correct sequence. The components handled have previously been percentage checked only and as they progress through the machine a number of dimensional and contour checks are made on them. Should a faulty component be encountered the machine automatically stops and the position of the fault is indicated to speed rectification and re-starting by a patrol operator.

The automatic assembly machine is illustrated opposite, together with an example of one of the eight types of assemblies it completes. It has twelve electro-pneumatic assembly heads, each of which is fed with stocks of components from either pre-loaded magazines, or by self-feeding hopper-loaded devices. The heads are mounted on an automatic indexing circular table which progresses the work-piece around the assembly stations in sequence. In this sequence the piston rod is automatically loaded from a magazine into the first station and stands vertically, with threaded end uppermost, in a bush. As the rod is indexed to each assembly head in turn, a component is automatically selected and placed on it until, at the last station, a nut is run on to the thread. The assembled unit is then lifted off the table and ejected down a chute to another machine which sets the nut to the required torque limits.

The machine is powered by compressed air taken from the mains at a pressure of 80 lb per square inch, and the air circuits are controlled by solenoid valves operated by a 110V circuit. Each of the twelve assembly heads is fitted with switches which relay its position to a main control cabinet so that all head and indexing movements are synchronised. Other switches on the heads detect the presence or absence of components and give appropriate signals to the main control cabinet signal lamps. In this way, the operator is immediately warned of any mal-functioning of the machine and can take corrective action.

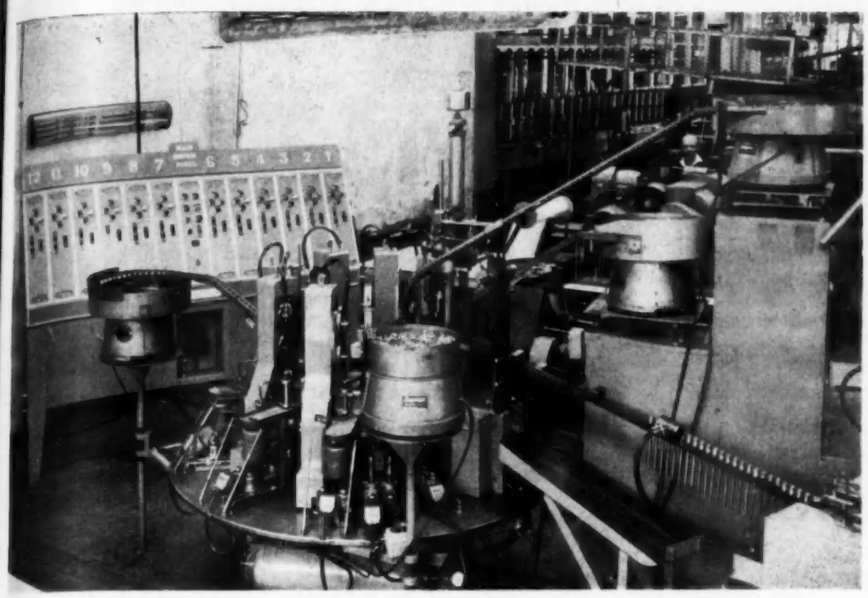
Six of the heads on the machine are of the vacuum pick-up design, and a quickly interchangeable spare head is kept on the machine. From a vacuum pump mounted under the indexing table feed lines are led to each of these heads through a ring main under the table. These vacuum heads pick up their components from rods mechanically pre-loaded with components. The other heads are fed from vibratory hoppers from which components gravitate down chutes fitted with traps and gates to position the components so that they reach the assembly heads correctly orientated.

The control panel situated apart from the machine, is connected to it by plug-in cables and sockets. Each head has its own packaged switch and control circuit and these are all immediately interchangeable. A spare unit kept in a special cabinet also acts as a test and fault detector circuit. If an electrical fault develops in one of the units it can be quickly detached from the control cabinet and the spare one inserted in its place. The faulty unit can then be fitted into the test panel, rectified and retained as the spare.

The mild steel platform of the cast iron indexing table is 6ft in diameter. Mounted above the table on a screw thread is a large duralumin ring in which there are thirty spring-loaded plungers, spaced equidistantly around the perimeter of the ring. These plungers provide the supports and retaining points to hold the piston rods in position for assembly. The object of this arrangement is so that five different lengths of piston rod can be dealt with. For the shorter lengths of rod the ring can be raised to the required position and locked.

Indexing of the table is effected by a large double-ended, finger-shaped cam plate. Beneath the table are fifteen roller races, spaced around the circle, on a fixed pitch diameter. An air cylinder operated by a solenoid valve moves the cam plate horizontally across the underside of the table on to the side of one of the roller races and moves the table in an anti-clockwise direction. A locking action is imparted by two centrally placed 45 deg. faces on the cam-plate which contact against the two roller races—the roller being pushed, and the one immediately behind it. Reversing the cam brings the

Fig. 13—The FR HR31-86 mounted tandem disc harrow

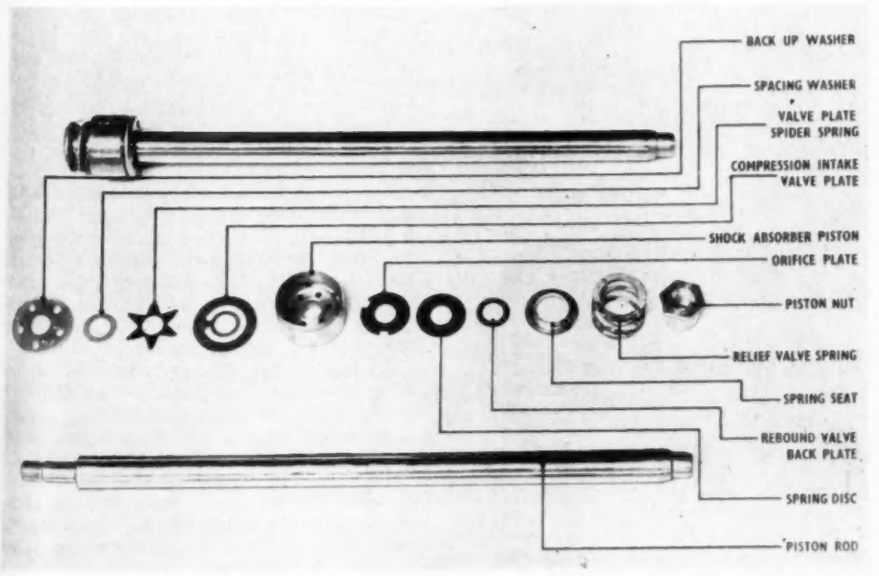


Machine for automatic assembly of shock absorber piston and rod assemblies at Vauxhall works

opposing cam faces into operation on to the roller races on the opposite side of the table and the process is repeated for subsequent indexing motions. Movement of the indexing cam-plate by air controls is so arranged that the initial feed is fast and the final indexing speed slow to eliminate rebound against the stops.

Components for the magazine-fed heads of the machine are loaded from a vibratory feed hopper on to rods at a nearby bench. The components are shims, varying in thickness from 0·004in to 0·008in and from $\frac{7}{16}$in to $\frac{3}{4}$in diameter. Because of their thinness, picking the components up by suction, one at a time, offered some difficulty. This problem was solved by incorporating a slight dwell period in the pick-off cycle, so that a small separator jet of air could be directed on to the suction head at the right moment, leaving only one component adhering to it.

The first component to be fed into the machine (to head No. 1) is the piston rod. The rods are laid horizontally on to a pair of roller chains, which feed them one at a time into a pivoting arm through a slot at the front of the hopper. When swung to its vertical position the arm drops the rod through into a bush on the indexing table, where it stands vertically, threaded end uppermost. At the second head a vibratory hopper feeds the next component—a back-up washer—via a chute into a selector chamber from whence the washers are delivered, one at a time, to the piston rods as they are indexed into position. The back-up washers must be positioned with their flanged edge uppermost, and if a washer with undersize bore is submitted, the rod, which is sitting on a spring loaded plunger, is pushed downwards, and the appropriate signal flashes on the control cabinet and the machine stops. The washers are pushed by a ram attached to an air cylinder, on to the rod via a trap in the platform built on to the selector chamber.



Shock absorber piston and rod assembly and component parts

The six heads which handle shim components are similar in design and operation, and deliver the thin steel components to the piston rod. The fabricated bodies of these heads are bolted on to the platform, and each has a lift and carry-over device operated by an air cylinder, in conjunction with a motorised magazine feeding arrangement.

Through the lift and carry-over mechanism a pick-off arm travels upwards in the vertical plane a distance of approximately $1\frac{1}{4}$in, then radially around the circle, for 110 deg. and then vertically downwards. At the end of the hollow spindle of the pick-off assembly is a suction unit, to which a component on the magazine rod adheres. The arm reversing motion follows the same path, and by turning the vacuum off and opening the line to atmosphere at the assembly station the component is puffed on to the waiting shock absorber rod.

As the components are picked off, the level of those remaining on the magazine rod is adjusted by an interlocking arrangement between the vacuum pick-off head and the motorised magazine rod. This rod is fitted into a screwed column geared to an electric motor which raises or lowers the components as the pick-off head dictates. Metal segments in the feet of the suction head act as detectors to ensure that pick-up has been achieved correctly, the component itself acting as contact to complete the electrical circuit.

The head at No. 6 station where the shock absorber piston is delivered functions in the same manner as that at the second station. The spring seat delivered at the tenth head is gravity fed down a chute from a vibratory hopper. These spring seat components are metered through a selector chamber one at a time, and allowed to slide down the chute on to the rod, it being possible to use this simple method because of considerable clearance between the rod and the bore of this particular component.

The relief valve spring which is delivered at the eleventh head is fed from another vibratory hopper to a gravity chute in the form of a tube which stacks the components one on top of the other. A trap-door above the table meters one spring at a time on to the piston rods.

The final operation at head No. 12 consists of screwing the piston nut on to the end of the piston rod, the nuts being fed from a vibratory hopper to this electro-pneumatically operated head. The nuts are metered one at a time to a carriage in the head, and as the carriage moves downwards holding a nut ready to be screwed to the piston rod, a pair of rubber-faced clamps grip the rod firmly. The nut is run on the rod several threads by a Desoutter nut-runner which, in place of the normal socket, has four spikes which bite into the top face of the nut. When the nut has been run the clamps lift the assembled unit off the table on to a chute which delivers it out of the machine to a separate torque setting machine.

This machine, designed by a group of the firm's young engineers, cost approximately £8000 to build, and with it new timings for shock absorber piston rod assembly output have been established. Previously each assembly was given a production time of 0·706 minutes whilst the new time is 0·27 minutes and represents an annual saving in the region of £9300.

A further assembly machine for assembly of shock absorber components is now reaching the final stages of development, and it will incorporate some new techniques including a pressing operation, and automatic setting arrangements for the nine different types of shock-absorber assembly now in production.

Wind Loads on Tall Buildings

Practically no observational data exists about the forces exerted by the wind on tall buildings. A research programme has just been initiated by the Building Research Station to remedy this state of affairs. Its aims and principles are discussed here. A gauge for recording wind pressures, as described hereunder, is shown installed at State House, Holborn, in the heading illustration.

A PROMINENT trend in the new architecture of the principal cities of this country lies in the increasing popularity of tall buildings—" point blocks " of flats or towers forming the focal interest of a large group of office buildings, for example. These tall buildings do not generally present unduly formidable technical problems in their structural design, but one aspect of that design, that of strength in relation to wind loading, is at present badly served by factual data, and present practice may prove to be somewhat conservative. Wind loading is computed by reference to a code of practice, namely British Standard Code of Practice CP3, Chapter V (1952), but the Code's stipulations for buildings more than 200ft high are not very precise* and a designer of a tall building must rely to some extent on his own particular preferences and experience. One of the difficulties lies in the absence of observational data on the forces imposed by the wind on a building.

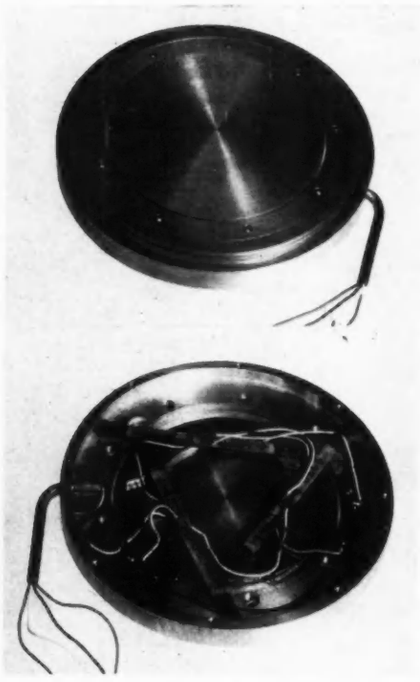
In recognition of this lack of somewhat fundamental knowledge, and also because revision of the code of practice is contemplated, the Building Research Station has recently started research into this problem. The work is at present in its early stages, so it is not possible yet to state anything firm in the way of results. Nevertheless the objectives which the work seeks to reach are worth an explanation.

Meterological observations of wind in this country relate principally to open country rather than to cities. The maximum hourly speeds and the speeds of gusts have been recorded, but what might be termed the " structure " of the wind (i.e. the pattern of gusts and turbulence and the dimensional scale of these phenomena), particularly in a city, has not been studied. One aim of the work now being done by the Station is to establish such information on wind structure in the London area. A principal objective will be measurement of the variation of wind speed, and the corresponding pressure it exerts on a building, with height above ground level. A second aim is to investigate the " micro-structure " of the wind insofar as this produces variations of wind pressures within the limits of the dimensions of a single building.

The work is of interest as probably the first serious attempt to measure these phenomena as they occur in nature, and the information gained will thus be rather different in character from that which could be obtained from a wind tunnel. The work is, nevertheless, being co-ordinated closely with wind tunnel tests at the National Physical Laboratory which are to some extent complementary, and equally closely with the Meteorological Office's observations.

Several tall buildings in London will be instrumented by the Building Research Station. The instrumentation is described in greater detail further on ; it is based on the use of a disc 4in in diameter, which is fixed flush with the face of a building, and the pressure exerted by the wind on it is measured.

The tallest building now being erected in London is the Post Office's 600ft tower at the Museum Telephone Exchange, Howland Street, W.1. The tower is circular, and so presents the same obstacle to winds from any direction. It has been the subject of wind tunnel tests with a model and the flow pattern around it, in a smooth airstream, is well understood. The tower is, therefore, an ideal choice for evaluating variation of wind pressure with height.



Pressure gauge for recording wind pressures. Note the flush external face (above) and the three phosphor bronze strips with strain gauges mounted in them, which carry the disc (below)

Gauges are to be installed at heights of 145ft, 205ft, 325ft and 506ft above ground level, at twelve equally spaced points round the circumference of the tower at each level, and at eight other levels spanning the height of the tower on the west and south-west aspects, as construction proceeds. A feature of the instrumentation will be the simultaneous recording of pressures on selected groups of instruments. Thus, with time, a valuable record of wind pressures will be built up. In addition, an anemometer will be installed at the top of a mast on top of the tower, so that a correlation between pressure and wind speed will be obtained at that height. Similar correlation at lower heights will be obtained by mounting anemometers on a nearby existing lattice mast. It is also intended to measure strain in the tower simultaneously with the wind loads, and for this purpose electrical resistance strain gauges are to be installed in the structure.

The second of the principal objectives, namely investigating the micro-structure of the wind, will be studied in more detail on a building of more conventional shape than the circular tower. A rectangular building with relatively smooth faces, so as to avoid the complications of turbulence introduced by heavy mullions and such like architectural features, was sought. For this, one of the tower blocks of the Barbican scheme was selected. Forty-eight gauges will be installed here, at three levels, four on each face at each level. The building will be 200ft high, but some correlation with the readings from the 600ft tower will be possible if the results obtained from it—which should be typical for such a structure—need to be extrapolated to greater heights.

Since construction of both of these buildings is at an early stage, and since, also, some information of wind loading is urgently required, more limited instrumentation of two existing buildings has also been undertaken. At State House in Holborn—the new headquarters of the D.S.I.R.—twenty gauges have been installed at heights of 110ft and 160ft on two faces of the building. Observation of these gauges is just about to start. Similarly, at the 387ft tower of the Vickers building at Millbank, eight gauges are being installed, at heights of 280ft and 360ft above ground level, and on the four faces of the building. The Millbank tower has a somewhat lozenge-shaped cross section, with two concave and two convex faces. This is not ideal from the point of view of the study, but it is nevertheless considered that valuable readings at greater heights

* Four " grades " of exposure are classified, and the corresponding " basic wind pressure " given for various effective heights of building between 10ft and 180ft. The maximum height listed for this " basic wind pressure " is " 200ft or more.'

possible than at State House will be obtained quite speedily.

When a sufficiently long campaign of observations of these *in situ* wind loading pressures has been made, and the results analysed, it should be possible, not only to relate the overall structural design of a tall building more rationally to wind load, but also to ascertain criteria for the strength of the relatively small elements used to clad it. The use of lightweight cladding, for instance, which is becoming more popular, presupposes a knowledge of the maximum positive and negative pressures which can act, under extreme conditions, on the area of a single panel. At present this is not known.

There is, in fact, almost a complete dearth of information of the kind sought in both the categories into which the research is divided. Durst* has, however, published results of studies of the dimensions and patterns of gusts related to thermal currents. There are a few American observations but they do not cover the ground which is now to be explored.

Related work on the stability of structures in winds has generally been based on wind tunnel studies. Results of several such researches have been published in THE ENGINEER from time to time—notably on suspension bridges. The National Physical Laboratory is doing complementary work on these aspects of the problem, we understand, one subject of study being aerodynamic buffeting when tall buildings are close together. It would clearly be an extremely formidable task to undertake strictly controlled measurements of buffeting on a full scale, but the Station hopes that its instrumentation will at least give some guidance on the problem. For instance at the Post Office tower at the Museum Exchange, some of the gauges will face a tall building about half a mile away, while those on another alignment will face a relatively unobstructed area. At the Barbican towers, comparison of results before and after the construction of other towers will also be possible.

INSTRUMENTATION

The measuring devite used for the Station's wind measurements consists of a circular disc of light alloy 4in in diameter, held flush in a circular housing by three phosphor bronze cantilever strips which are anchored behind the edge of the housing. A plastics seal is fixed between the disc and the housing to exclude wind pressure from the back of the disc.

Each phosphor bronze strip has two pairs of strain gauges mounted on it, at about its quarter points, such that when it flexes, one gauge of each pair is in tension and one in compression. A Wheatstone bridge circuit is wired so that the twelve gauges act cumulatively, and at the same time provide temperature compensation. The chamber on the inside of the disc is piped to a common point for the whole installation, so that all instruments have the same back-pressure.

A load of $\frac{1}{4}$ lb per square foot can be measured by the instrument, up to a maximum load of about 50 lb per square foot which covers the whole range of pressures needed for the work. The instrument is sensitive to cyclical variations of pressure as rapid as 10 c/s.

Simultaneous recording of all gauges in an installation is achieved through a battery of amplifiers, &c. The first stage of the work will be recorded graphically, but later records will be made on magnetic tape to facilitate processing of the data.

* *Meteorological Magazine*, Vol. 89, July, 1960, pages 181–86.

Development of Dip. Tech. Courses

ON Wednesday last week we had the pleasure of attending a function at the Battersea College of Technology, the Presentation of Diplomas and Diplomas in Technology, the first occasion on which such a function has been held at that College. Dr. Leggett, Principal of the College, reported on its work, and after the Diplomas had been presented Sir Harold Roxbee Cox gave an Address. Below we print extracts.

Dr. Leggett: There are in the College 1275 full-time students. Of the total number of full-time students who attended College last session and who took their finals in the summer, 138 were awarded a B.Sc., and eighty-two a Diploma in Technology. As an indication of the amount of post-graduate work now going on, I might mention that twenty-six Higher degrees were awarded last session to research students and one or two members of staff, and that twenty-nine post-graduate students now hold D.S.I.R. Research Studentships—a larger figure than for several universities. Two post-graduate students have registered for the National Council's higher award of the N.C.T. If this seems rather small I would quote a Chinese proverb, "The longest journey begins with the first step," and express the hope that this figure will steadily increase. Which leads me to make a few remarks about the place held by the Diploma in Technology at this College.

At the start of this session the number of new registrations was 125, as large a number as we have yet had, and, space permitting, I hope that this number will steadily increase for eventually we should like the degree and Dip. Tech. streams to be of roughly equal strengths.

The present period is a very exciting one for Colleges of Advanced Technology. One has but to consider the implications of the take-over bid by the Ministry of Education to which all the shareholders have now given their consent, albeit with some reserve, and the formation of the Robbins Committee and published evidence which has been submitted to it.

The Ministry of Education has recently informed the Governing Body that it envisages this College increasing its number of full-time students to 2000, though not of course immediately. With its present number of 1275 full-time students the College is already desperately over-crowded. What is to be done? In particular, does the College remain on its present site or move elsewhere? This problem is under active consideration by the Ministry of Education, the London County Council, and, of course, the Governing Body. To find a satisfactory solution presents a very real challenge and two qualities are called for from everyone concerned with the future of this College—Vision and Courage. Vision because the decision made will be irrevocable and will determine the future development of the College for many years to come. Courage, because whatever decision is reached it is most unlikely to receive universal approval.

Sir Harold Roxbee Cox: The N.C.T.A. which was set up to create and administer awards in technology, is barely six years old. Its early years were of course devoted to the formulation of its first award, the Diploma in Technology, and now to-day there are over 5000 students following courses leading to the Diploma. That overall figure gives an idea of how this new award has supplied a need. The Diploma is developing, of course, very strong characteristics of its own. We have said from the outset that the Diploma course would be of the standard of a university honours degree course. We have never said that it would be like a university honours degree course. Some people think it is too like. There are, indeed, points of similarity, but there are many points of difference. We have always believed that the integration of the practical and academic sides of education and training are of the greatest value, and it is in this respect that I believe the Diploma is most different from other awards of equal standing, and it is in this respect that I believe the Diploma is making a new contribution to education in this country. We do not, however, want to make Diploma courses different from university courses just for the sake of being different. We must always try to build a new Diploma course to fulfil its objectives in the most efficient way, and if, in the result, the academic part of the course bears a resemblance to a university course in the same subject, well, unlike some people, I do not feel that is a cause for criticism.

I would not like anyone here to think that my interest in the Dip. Tech and its development means that I am, *per contra*, critical of university education and courses for university degrees. I am not. I hope that in no one's mind is there the idea of competition between the two great kinds of institution. They represent different approaches in education and they must both develop naturally, developing differences and developing similarities. I do not know whether they are going to get more different or more alike, but the particular case of Battersea, with education for university degrees and for Diplomas in Technology proceeding side by side, may well provide a development of almost biological significance.

What I confess I do hope is that in the development of the colleges of Technology we shall see the continued development of the Diploma of Technology. In the N.C.T.A. we look forward to the day when the colleges of advanced technology become autonomous. The colleges, too, look forward to this landmark in their progress. The colleges will then be empowered by Royal Charter to make awards in their own right. It is my sincere hope—my personal hope—I am not speaking for the N.C.T.A., for the D.S.I.R., or for industry—that they will not at that time change the name of the award on which they are building their reputations—the Dip. Tech. There are people in the colleges of advanced technology who talk of awarding Bachelor of Technology degrees to compare with, or compete with, the universities' Bachelor of Science. They seem to feel that a bachelor is superior to a diplomate. Speaking as one who is both, I must say I don't. Indeed, I regard my Diploma of the Imperial College as the most distinguished of the awards for which I worked as a young man. I would like to feel that the degree for that particular kind of education in which academic and practical training are integrated is the Dip. Tech., whether in university or college. In the immediate post-graduate stage, I know of no more distinguished award than the D.I.C. On the Continent the Diploma Engineer has the highest possible graduate status. Dip. Tech. itself to-day has the standing of an honours degree. I suggest to the colleges which look forward to autonomy that the important thing is the Royal Charter which defines their independence and authority. I would agree that in comparison with that, names are secondary. But I do say this: a degree, according to the O.E.D., is an academical rank conferred by a university or college as a mark of proficiency in scholarship. The dictionary does not say that one who gains it is called a bachelor or a master. If, in university or college, a degree is awarded for the kind of course which in the past has led to a bachelor's degree, let us so call it. But if it is for the kind of integrated course in technology which now leads to a Diploma in Technology, let us continue to use that term.

The name of the National Council for Technological Awards suggests that it is concerned with more than one award. For the first three or four years it concentrated its attention on the Diploma in Technology. More recently it has instituted a higher award, which is called Member ship of the College of Technologists. The College of Technologists is an academic entity comparable perhaps in form, though certainly not yet in importance or size, with the Royal College of Surgeons. Membership of it will signify very high distinction and will be awarded for an investigation in which both industry and a college are concerned. It is quite unlikely

that anyone will be able to gain the M.C.T. until a few years after getting a first degree or Diploma in Technology, and the majority of people who do ultimately obtain this award will probably be people who have worked for some time in industry before achieving it. So far there are about forty people registered as candidates, two of them in association with this college. Just as the universities are accepting appropriate diplomates as candidates for their higher awards, so will the National Council accept appropriate university graduates as candidates for the M.C.T.—indeed, some of the present candidates are university graduates. Once again the National Council believes that it has created a new award which will have its own place in the post-graduate spectrum. It is not intended for the same kind of achievements as merit D.Sc.'s, Ph.D.'s and M.Sc.'s. It will have, we hope, its own qualities, and prominent among those qualities will be the special flavour which research and development projects in industry can give.

I have spoken at considerable length about the two awards of the National Council and I have probably bored a great many people here excessively in doing so. I am sorry that that should be so, but I do not apologise because I believe it is most important that everyone should be aware of their characters and aims. There have always been large numbers of people for whom the university as we have known it was not the most suitable kind of place. They are the people whose inclination at an early age has been to start work in industry—the sort of people who have been the backbone of the great British apprenticeship system. Amongst these people there have always been many of high talent whose achievements were not properly rewarded by a Higher National Certificate. These people have many times demonstrated their ability to compete with the university graduate, but they have not until recently been given a mark of distinction which showed to the world at large—and, more important perhaps, to the prospective employer—what their abilities were. Again, there have been people whose abilities in industrial or engineering investigations matched the abilities of those who, in the universities, could, by research, gain a D.Sc., or a Ph.D. Such people can now aim for an M.C.T. It is important in the modern world that ability should be labelled. We do not want roses to blush unseen.

Fast Patrol Boat "Ferocity"

SMALL fast warships have for many years engaged the attention of Vosper Ltd. and before the war the company built as a private venture a motor torpedo boat which was capable of a speed of 44 knots when fully equipped with guns, ammunition and two 21in torpedoes. Both during and after the war Vosper Ltd. completed a number of M.T.B.'s and the latest of this class of craft are the fast patrol boats "Brave Borderer" and "Brave Swordsman." These craft have a standard displacement of 75 tons and a full load displacement of 100 tons, have a waterline length of 96ft by 25ft 6in beam and are powered by three Bristol "Marine Proteus" 1250 gas turbine engines, developing a total of 10,500 s.h.p., which gave the boats a speed of 50 knots on trial. Since then Vosper Ltd. has been engaged on the development of a smaller and lighter craft designed to have high speed and good sea keeping qualities and to carry the same armament as the "Brave" class. As a result of its endeavours the company, as it did before the war, has built as a private venture the fast patrol boat "Ferocity" which was recently demonstrated in the Solent area.

This craft has an overall length of 90ft 8in, a moulded length of 88ft, a moulded beam of 22ft and an average displacement of 75-85 tons and is powered by two Bristol Siddeley "Marine Proteus" engines which have been uprated to 4250 h.p. The hulls of the "Brave" class are built of double skin mahogany planking fastened to welded aluminium alloy frames, whereas the new boat has a hard chine hull of homogeneous construction in which the outer skin is bonded to laminated wooden frames with a resorcinol or phenolic adhesive, so that there are no large changes in stress when the boat is at sea. A thin skin of glass fibre protects the skin from damage by marine borers and also avoids increase of displacement by soakage. This particular form of construction lends itself to mass production and any damage can be easily repaired. The superstructure is of aluminium alloy. As can be seen in our illustration of "Ferocity" on trials the boat is armed with two 40mm Bofors guns and four 21in torpedoes. Normal armament is four torpedoes with side launching gear and one gun, or two torpedoes and two Bofors, or eight groundmines and one gun. Furthermore the design provides protection against atomic, bacteriological and chemical attack and the wheelhouse and forward accommodation can be made into a gas-tight citadel while provision has been made for spraying the bridge and upper deck. Navigational aids installed include a Decca mark TM 909 radar, a "Chernikeeff" Log, a Kelvin Hughes echo sounder, and a Sperry Marine "Gyrosyn" compass which maintains accuracy during high speed manoeuvring and is compact and of light weight. In association with the compass is a Sperry Tiller Pilot for automatic steering. Steering is by twin rudders and Mathway power assisted steering gear incorporating a two-speed box for hand operation.

The two Bristol Siddeley "Marine Proteus" 1270 gas turbines are the main propulsion units and each has a maximum rating of 4250 s.h.p. and a continuous rating of 3400 s.h.p., at an ambient temperature of 60 deg. Fah., burning light marine gas oil. These engines, depending upon loading and ambient temperature, give the boat a maximum speed of 50 to 54 knots and a continuous speed of 42 to 46 knots, the endurance at the latter speed being 400 nautical miles. To enable the boat to carry out long patrols at slow speed two Mathway-Daimler diesel engines having a continuous rating of 150 b.h.p. are mounted and these give a cruising speed of about 10 knots and an endurance at this speed of 2000 nautical miles. We include a general view of the machinery space. Dimensions of the "Marine Proteus" are length 112in by 42·9in wide and the bare dry weight is 2885 lb equivalent to 0·68 lb per h.p. including the reduction gearbox, or 1·32 lb per h.p. including full reverse/reduction "V"-drive gearbox. The unit, which has a life of 2000 hours between overhauls, is of free turbine design with the power turbine mechanically separate from the compressor and its turbine, so that the compressor can always run at optimum speed.

To accommodate the separate main engines and cruising units Vosper Ltd. has designed in conjunction with Bristol Siddeley Ltd., David Brown Industries Ltd. and E.N.V. Ltd. a 22 deg. "V"-drive reduction gearbox which is capable of accepting a drive from either sets of engines. An idler in the port gearbox provides for the outward rotation of the propellers with the unidirectional gas turbines. The cruising diesel engines incorporate their own means for reversing so that the gearbox is not arranged for reversing. The shafting is of Monel metal with the propellers shrunk on and the propulsion arrangements result from studies made in the company's cavitation tunnel. Exhausts from the gas turbines are through the upper transom and are protected by a shelf while hinged flaps protect the exhaust outlet in the event of a turbine being stopped. There is also a transom flap to adjust the trim as required. The necessary electrical power is provided by two Rover gas-turbine-driven generators mounted in the engine room wing spaces.

Fig. 1—Fast patrol boat "Ferocity" at speed

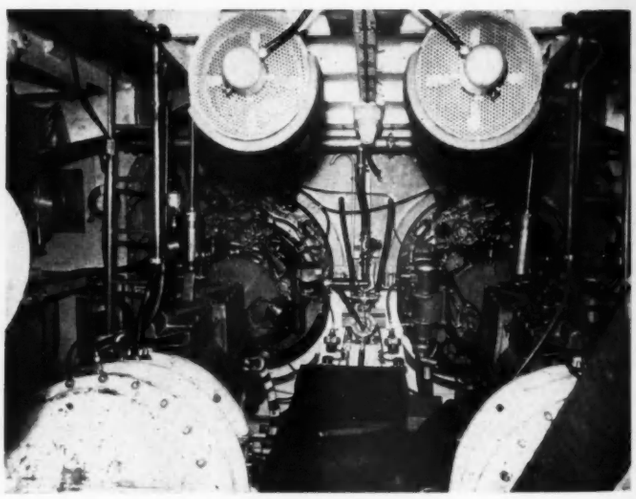


Fig. 2—View of engine room looking aft

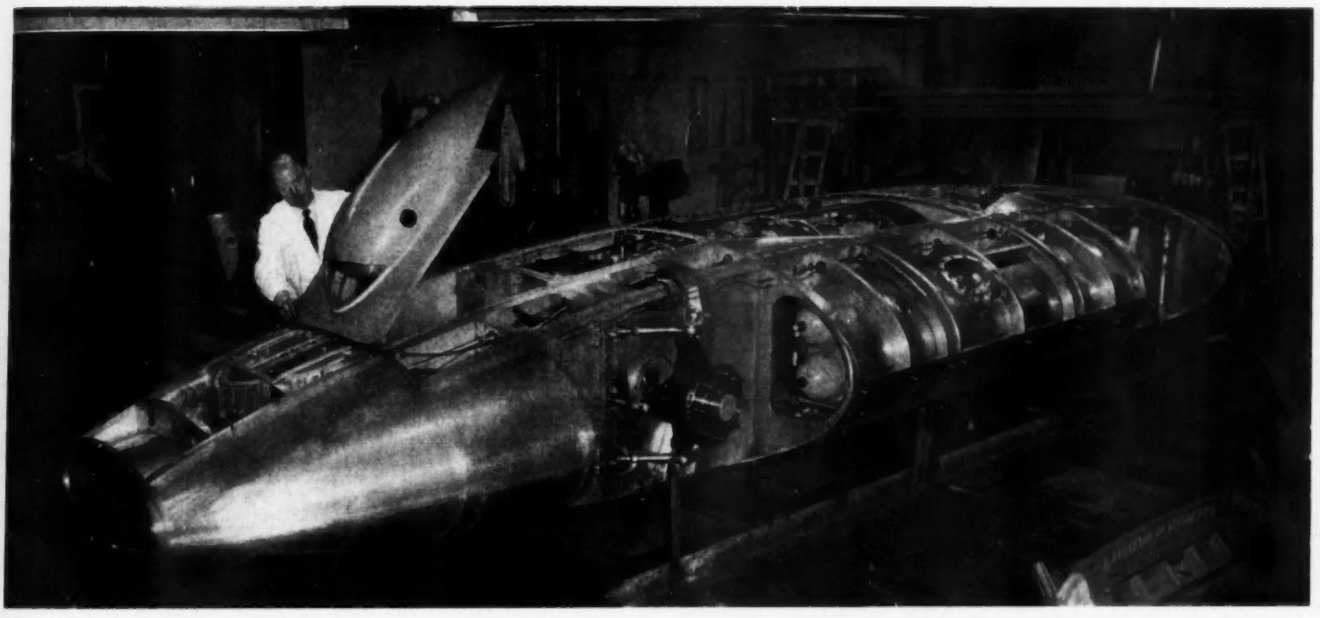
POLYPROPYLENE.—Blocks of polypropylene are now being produced by Frederick W. Evans Ltd. in sizes up to 12in by 12in by 1in suitable for the machining of prototypes.

SHORTER REPORTS

British Iron and Steel and the Common Market

MR. C. R. WHEELER, President of the British Iron and Steel Federation, speaking at a recent meeting of the Iron and Steel Institute in London, said "The great weight of opinion in the British iron and steel industry welcomes the Government's decision to apply for full membership of the European Communities and hopes that the negotiations now under way will soon be brought to a fruitful conclusion." He commented that on the question of trade in general, taking the field as a whole, and bearing in mind that the Community market is a sophisticated one well suited to the British industrial pattern, he had no doubt that the British steel-using industries stood to gain from bigger exports to Europe. "The Industry hopes," said Mr. Wheeler, "that the entry into Europe may eventually bring still further gains through its revitalising effect on the economy as a whole." It is unlikely that there will be any sudden increase in deliveries of British steel to Continental markets, or any large influx of Continental steel into Britain. *vis-a-vis* Continental producers have been progressively lost in recent years. For example, since the E.C.S.C. started to operate, the pithead price of British coking coal has risen by nearly 60 per cent, whereas the prices of Community coking coal have not risen by more than 16 per cent anywhere, and in some areas have actually fallen. Some Community steelworks are being developed on coastal sites to import cheap American coal on a regular basis, whereas British coastal plants are forced to rely on home supplies which are, in one case which comes to mind, some 30s. a ton dearer. Mr. Wheeler made the British industry's position in this matter quite clear. If the British Government decides to place the British steel industry in more competitive conditions as regards end products, then it must equally ensure more competitive conditions in the matter of fuel supplies.

Mr. Wheeler was confident of the technical strength and competitive ability of the British steel industry, provided that it is allowed to compete on equal terms. On such terms he felt that the industry would welcome any competition it had to meet, and he had no illusions about



The reconstructed "Bluebird" early last week. The oval opening on the port side gives access to the gas pressure gauges and control valves. One of the built-in jacks can be seen in the rear wheel well. The steering arm is not integral with the hub carrier but attached by slotted holes, so that adjustment of castor does not entail departure from perfection in the steering geometry

Steel, which has high transport costs in relation to its value, tends to be made mainly for national markets. It is to indirect rather than direct exports that the British steel industry looks for its early gains.

"The essential thing now is to increase the industry's capacity to sell steel, both by improving the cost efficiency of our plants in every way possible, and by improving our sales machinery in all its aspects." Mr. Wheeler pointed out that there are many differences in detailed organisation between the British steel industry and the European Coal and Steel Community, of which the British industry would become a member if the negotiations are successful, but added that there are ways of surmounting the difficulties which would arise. He added "... the industry is of the opinion that Britain's entry into the E.C.S.C. would require an urgent reassessment of national fuel policy." The sizeable cost advantages which the British steel industry has had the fact that Continental producers would try hard to sell steel in Britain. To counter this he knew that British steelmakers would do their best to break into the wider Continental markets. "Competition of this sort," he said, "is good all round."

Land Speed Record Contender

THE CN-7 "Bluebird" designed by Norris Brothers Ltd. for Mr. Donald Campbell, chairman of the firm, to drive in an attempt on the world land speed record, is now nearing completion of reconstruction after the accident that terminated the attempt at Bonneville Salt Flat in 1960 (see Plate 20, January 13, 1961). The original body shell was scrapped, honeycomb-stabilised sandwich being almost impossible to repair, but much of the machinery, and in particular the "Proteus" free turbine, is being used again. The rebuilt car has reached the stage where all the main components and services are installed in the shell and skinning is in progress. It is expected that the car will undergo testing, including engine running, at a standstill by the end of this year and then be loaded on its trailer for transport to the scene of the attempt, where the first running on its wheels will be done.

The new vehicle is basically the same as the original one, but the transparent canopy has been replaced by a glass-fibre-reinforced moulding. The fuel stowage is now on one side only, to expedite refuelling, and the compressed gas reservoirs and control panel have now been moved from the tail to the side opposite the tanks. This will allow a tail fin to be added to increase the damping in yaw, if trial running shows it to be an asset. The presentation of speed and acceleration signals to the driver (by projection on to a panel within the windscreen) will use simple figures, relying on the driver to distinguish and interpret them.

The Bonneville salt flats in Utah were last year in a very poor condition, due to there having been little rain for some years and to the lowering of the water table involved in the extraction of potash, and the scene of the new attempt is expected to be at Muloorina on Madigan Bay in Lake Eyre, a salt pan in South Australia. This has two major advantages over the lake in Utah: that it is flooded only once in a few years, so that attempts need not be hurried, and that the adhesion is greatly superior, possibly due to the presence of sand in the salt. However, the surface is interrupted by ridges of very hard salt, possibly caused by the effect of wind when the pan is drying out, and to obtain a course of the desired length—about 20 miles—it will be necessary to clear away numbers of these ridges. The ridges are too hard to scrape away and come away in chunks, leaving jagged holes, if graded; but the feasibility of removing them as powder with a very large milling cutter has been demonstrated. The actual clearing of a course and the establishment of access roads and an (artesian) water supply, however, can only be done by the public authorities in the State.

SHORTER REPORTS *(Continued)*

300MW Turbo-Generator in Service at Lakeview, Ontario

THE 300MW Parsons turbo-generator now in commercial operation at Lakeview power station is the largest turbo-generator in service in the British Commonwealth. It is the first of two 300MW sets ordered from C. A. Parsons and Co. Ltd. by the Hydro-Electric Power Commission of Ontario, for installation at Lakeview. It is a cross-compound machine: one line consists of an h.p. and i.p. turbine driving a 150MW generator at 3600 r.p.m.; the other line consists of a second i.p. turbine and two double-flow l.p. turbines driving a 150MW generator at 1800 r.p.m.

The operating steam conditions at the stop valve are 2350 lb per square inch at 1000 deg. Fah, with reheating between the h.p. and l.p. cylinders to 1000 deg. Fah. The generators are hydrogen cooled and operate at 11kV, 60 c/s, 0·8 p.f. Each rotor is direct cooled by hydrogen at 30 lb per square inch.

Both generators are designed and equipped to enable them to be operated as synchronous condensers, in which condition the generator rotors would be disconnected from the rotor shaft.

High-Voltage Electricity Supply for H.M. Dockyard, Chatham

H.M. DOCKYARD, Chatham, which since 1905 has generated its own electricity for warship building, maintenance and repair, on Monday, November 27 was connected to a new high-voltage supply and distribution system connected with the national electricity grid system and the dockyard turbine generators were shut down for the last time. The new 11kV ring-main system which replaces the dockyard's own generated 3·3kV supply cost about £250,000.

Dockyard consumption of electricity has risen considerably in recent years and now amounts to over 50,000,000 units a year at Chatham. When the dockyard station was opened in the early 1900's it supplied about 1500kW of plant, and this progressively increased to 12,000kW in 1935. To-day the demand has risen at Chatham Dockyard to over 16,000kW.

The supply is taken from the South Eastern Electricity Board's 33kV system via a dockyard substation at Upnor, stepped down to 11kV and led by submarine cable across the River Medway via two routes into the ring main system covering eight distribution substations and another substation on a spur feeder. Existing standby supplies derived from another point in the Area Board system are led into the ring main at two of the substations. All the substations are dispersed round the dockyard and accommodate all necessary switchgear to enable dockyard loads to be energised either direct at 11kV or at 415V with remote control at a central control room.

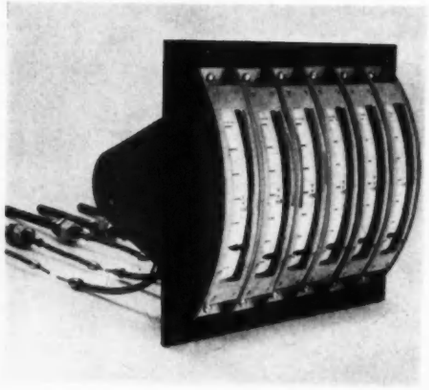
Commissioning of the new system and the closing down of the generating station will lead to considerable economies in fuel consumption, and enable former operating and maintenance personnel to be employed on other work. Part of the existing generating station will be used to accommodate frequency changers for converting the 50 c/s mains supplies to 60 c/s, necessary for supplies to warships of the Royal Navy and N.A.T.O. countries now using a.c. systems. Rotary converters providing direct current to dockyard services will remain in the station buildings.

The switchgear, transformers, control equipment, &c., was made and installed by the English Electric Company Ltd.; the power and control cables by Enfield-Standard Power Cables Ltd. About forty-four circuit breakers and twenty transformers have been installed in the nine substations within the dockyard, connected by 9 miles of high-voltage power cable and 500 miles of control cables.

Plans exist for the possible extension of the system to meet additional loads arising from extensions to the dockyard workshops and resources generally. These plans provide for a total of seven substations at a cost approaching £750,000.

Vertical-Scale Thermometers

A BANK of six mercury-in-steel thermometers of the new model 605 produced by the British Rototherm Company Ltd., Merton Abbey, London, S.W.19, as illustrated, occupies a space 9¾in deep by 11½in wide overall. The scale of the thermometer is 7½in long and under 2in wide, and its range is within the limits of mercury, namely −30 deg. Fah. to +1200 deg. Fah. and equivalent Centigrade. In addition to the saving in space (at least 4in diameter dials would



Bank of mercury-in-steel thermometers arranged for easy comparison of six temperature points

otherwise be needed) comparative readings of a number of temperature points can be made at a glance when the units are assembled in banks as shown, any number required being arranged in this way.

The thermometer scale has an unbreakable window surrounded by a chromium plated flange. Each instrument is housed in a light alloy casting. Zero adjustment is by an easily accessible screw. The standard copper-sheathed capillary is 10ft in length with 6in of stainless steel armoury at head and back. Lengths of up to 120ft capillary can be supplied.

[Reply Card No. 1457]

Telemetering System

CONVERSION of instrument readings into a code based on variable pulse widths is the principle of the "Dur-O-Pulse" industrial data transmission system now available in this country from Honeywell Controls Ltd., Greenford, Middx. The system is adaptable to the measurement requirements of electricity, coal, gas, water, chemical, petroleum, steel and other industries. It will convey indication and control signals over distances up to 100 miles without repeaters by means of a single pair of wires, or by microwave radio or power line carrier links.

Basically the equipment comprises a power pack, an indicator transmitter, and a recording receiver. The transmitter is a standard Honeywell indicating, controlling or recording instrument adapted to produce the code signals. This is accomplished by the interaction of a scanning unit and a vane. The lightweight aluminium vane is linked to the instrument pointer or pen, which governs its position. In order to detect this position and encode it for transmission, a scanning unit consisting of two coils mounted on an arm driven by a cam is caused to intercept the arc traversed by the vane as it follows the pointer movements. The coils are part of a tuned plate, tuned grid oscillator which operates at approximately 19 Mc/s when the vane is not between the coils. As soon as the coils intercept the leading edge of the vane, the change in mutual conductance throws the oscillator off tune, and the rise in anode current operates a relay to initiate transmission of a pulse, which continues until the coils are clear of the vane. The time during which the coils are traversing the vane varies according to the angular position of the latter. There is a six-second differential between the pulse length for zero and for full-scale deflection of the instrument pointer or pen.

At the remote receiver the pen is positioned by the operation of two gear sectors driven through electromagnetic clutches by a synchronous motor. The clutches are energised alternately by "on" and "off" pulses corresponding respectively to the periods when the transmitter relay is energised and when it is released. Assuming the measured variable to have increased, the upscale drive clutch in the receiver will be engaged for longer periods than the downscale clutch, and the pen will move upscale to a new position. The reverse action takes place for lower readings.

Either d.c. or a.c. impulses can be used. With d.c. transmission, the closing of the transmitter relay allows current to flow round the transmission channel from the power equipment at the receiver site. This operates a detector relay in the receiver with normally-open and normally-closed contacts. The alternate operation of these contacts completes a circuit from a 50V, 110mA d.c. source in the power supply to energise either the run-up or the run-down clutch in the receiver mechanism.

The transmitters and receivers themselves operate on 120V a.c., and if the transmitter pulses are to be a.c. the necessary voltage is impressed on the line at the transmission site instead of from the receiving end as described. It is also possible to use d.c. pulse transmission and take a.c. power for the transmitter from the receiver site over the transmission line. A further possibility is duplex transmission in which two transmitters sending d.c. and a.c. pulses respectively share a common channel.

[Reply Card No. 1459]

Heavy Gauge Tinplate at a Competitive Price

TINPLATE offers many advantages for producing articles other than the food containers with which it is normally associated. It provides good paint adhesion, suitable surface conditions for processing and plating, excellent ductility and a saving in die costs as the tin coating acts as a lubricant. The tin can take the place of a priming or phosphate coating, and de-greasing can be eliminated. In the past, however, tinplate in the heavier gauges was at a disadvantage as regards cost. It was made by the hot-dip process, and inevitably carried a heavier, and therefore more costly, tin coating; this was inherent in the process, and could not be avoided.

The problem has now been overcome by the Steel Company of Wales Ltd., Abbey Works, Port Talbot, which is producing tinplate up to 0·0237in thick with the tin coating deposited electrolytically. By using the electrolytic process it is possible to control the tin thickness much more accurately than by the hot-dip method, and coatings as low as 4 oz per basis box are now being offered in the heavier gauges. This tinplate, up to 0·0237in thick (nominally 24 B.G.) is now available at less than £60 per ton.

[Reply Card No. 1469]

Transatlantic Radio Jubilee Exhibition

FROM next Wednesday, December 13, to January 25, 1962, an exhibition will be held at the Science Museum, South Kensington, London, S.W.7, to celebrate the first spanning of the Atlantic by wireless the successful culmination of the experiments by Guglielmo Marconi in spanning the Atlantic by wireless telegraphy. This was accomplished on December 12, 1901, when signals consisting of a repetition of the Morse letter "S," transmitted from a station at Poldhu in Cornwall, were heard by Marconi and his assistant, G. S. Kemp, at Signal Hill, Newfoundland. The exhibition will show items of equipment from Marconi's laboratory representative of practice at this period, such as coherers, telephone receivers and kites for supporting aerials. His diary and personal belongings not previously shown in public will be on view. Among many historic exhibits and original photographs, a notable feature of the exhibition will be a recording of Marconi's voice telling in his own words how success was achieved.

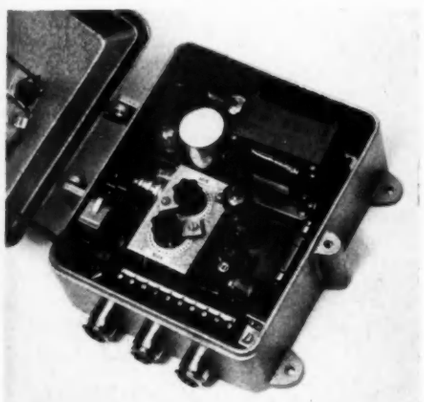
Resistance Welding Alloy

THE introduction of a new resistance welding electrode alloy, Mallory 328, is announced by Johnson, Matthey and Co. Ltd., 73-83, Hatton Garden, London, E.C.1. Developed from long-established Mallory 3, the new alloy has an equally high electrical conductivity with slightly greater hardness at room temperature. The outstanding characteristics of Mallory 328 are its better retention of strength and hardness at higher working temperatures, its superior elongation, and its greater resistance to cracking under severe welding conditions. These factors are expected to make it an excellent electrode material for welding all types of steel, especially coated steels. Mallory 328 rod is available from stock in a number of standard sizes. Other sizes of rod, seam welding wheels, and forged bars are produced to order.

[Reply Card No. 1442]

Remote Level Control

A CAPACITATIVE system for the measurement and control of level in silos, bunkers, and so on, without restriction on the distance between the measuring electrode and the apparatus, is available from I.E.C. Electronics Ltd., 39, Parliament Street, Westminster, London, S.W.1.



Oscillator and amplifier unit of capacitative level measuring system

The equipment has been developed by the firm of Grieshaber Brothers. While based on the change of capacitance between an electrode and the container wall, it does not require a coaxial connection between the remote oscillator and the electrode. An h.f. voltage is supplied to the electrode through an impedance-converter in the head of the latter, enabling the source of oscillations to be of low impedance. Changes in capacitance due to varying contents level in the container cause a change of voltage in a bridge circuit. This change is rectified by a silicon rectifier in the head of the electrode and fed back over the connecting cable to a high-impedance, stabilised two-stage amplifier in the control unit (illustrated).

One or more measuring instruments can be connected to the amplifier output to give continuous level indication. Alternatively, a switching amplifier can be installed which triggers a thyratron when the voltage corresponding to a particular contents level is reached, so that a pulse can be derived from a thyratron-controlled relay. The combination of a low-impedance r.f. input to the electrode and a return d.c. path at relatively high impedance enables the connection between the electrode and the amplifier to be of ordinary cable without special screening, and of any length likely to be required in practice without affecting accuracy of measurement.

[Reply Card No. 1454]

Relay for Pneumatic Control Systems

AN air-loaded precision relay produced by the instrumentation division of Associated Electrical Industries Ltd. for pneumatic control systems can be incorporated at any point in a control circuit where a varying air pressure is required to switch a separate air supply from one circuit to another. By using air pressure to control a relay in this way it is possible both to control the operation remotely and to monitor on a gauge the pressure about which it is operating.

The new relays can be used as on/off controllers operating at pre-set levels to initiate alarms or, because of an inherent stability, to operate air pressure-conscious electrical switches. Two relays used with a double-acting air-operated changeover valve can provide on/off control plus the facility of being able to adjust the change in the pressure (or differential) of the controlling air supply needed to operate the system.

The relays operate over an ambient temperature range of −60 deg. Fah. to 180 deg. Fah. Their controlling pressure range is normally 3-15 lb per square inch but a relay will operate at up to 100 lb per square inch while the pressure of the air supply to be switched is a maximum of 100 lb per square inch. The variation of pressure required to operate a relay is less than 0·12 lb per square inch with a repeatability of within 0·03 lb per square inch.

[Reply Card No. 1422]

Modification of Victoria Line Project

LONDON TRANSPORT states that the plans for the proposed Victoria tube railway line in the Walthamstow area are being changed. The line will not terminate at Wood Street station of the Eastern Region as originally intended, but at Hoe Street station, which is in the centre of Walthamstow approximately ¾ mile on the London side of Wood Street. Interchange with the Eastern Region electrified services to Highams Park and Chingford would be provided at Hoe Street instead of at Wood Street as hitherto planned.

The Eastern Region line through Walthamstow to Chingford has now been electrified on the high voltage system and major alterations which would be required to the layout of track and to the overhead electrical equipment at Wood Street would be prohibitively costly if that station were to become the terminus of the Victoria Line, it is stated. The revision of plans will allow a reduction, of the order of £1,400,000, in the capital cost of the Victoria Line if it is built and satisfactory interchange could be provided on the new site.

Ferrous-Metal Cleaning Solutions

Two new solutions which are stated to enable de-greasing, de-rusting and de-scaling of ferrous metals to be done simultaneously in one tank have been developed by Grant and West Ltd., of Stoke Mill, Guildford, Surrey. One of the two solutions, known as "ChemiClene No. 437," is used for the removal of oil, grease, light rust and welding scale, and the other, "ChemiClene No. 447," for removing oil, grease, heavy rust, welding scale and mill scale.

These solutions, when diluted with water and heated to between 40 deg. and 50 deg. Cent., emulsify the oil and grease so that they are removed in a following water rinse; at the same time rust and scale oxides are removed by chemical action.

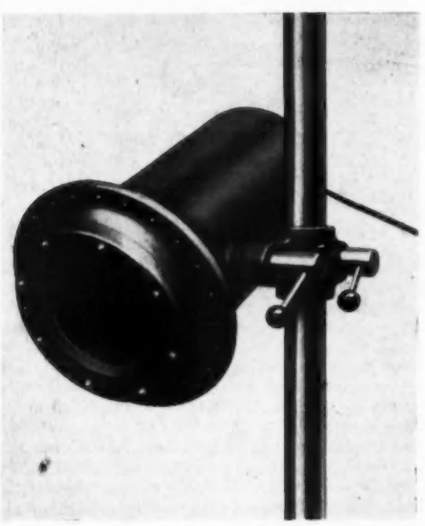
The time varys according to the amount of contamination, but the makers say that with "ChemiClene No. 437" the average time required for cleaning should be between three and eight minutes, while with "ChemiClene No. 447" oil, grease and light scale is removed in ten to fifteen minutes. "ChemiClene No. 437" is non-corrosive and is suitable for the treatment of partially fabricated work where some of the liquid could be trapped between seams, spot welds and in other places.

[Reply Card No. 1392]

Closed Circuit Television Lighting

DUST-TIGHT and watertight lighting fittings, designed specifically for industrial closed circuit television installations, have been introduced by P. W. Allen and Co., 253, Liverpool Road, London, N.1. Applications in view are in explosives factories, nuclear establishments, chemical plants, aero engine and rocket motor test cells, and similar places with exacting ambient conditions. One standard housing is made to take a focusing spotlight, fixed focus spotlight, or floodlight lamp of from 100W to 250W, according to camera lighting requirements and the permissible surface temperature of the fitting. Lamps may be operated at mains or lower voltages.

As seen in the illustration, the body of the lamp is a "top hat" section spinning in 16 gauge steel, 14in by 8½in diameter. Riveted to the front flange is a heavy machined cast aluminium ring, 12in diameter. Screwed to this is another machined ring into which is cemented the 6in diameter, ¼in thick, glass window. The fitting is finished in silver grey hammertone high-temperature stove enamel over cadmium plate.



Adjustable lighting fitting for industrial closed circuit television installations

For mounting, a ½in spigot welded to one side fits the clamp, which in turn fits over a 2in diameter column, making the fitting fully adjustable in all directions. The fittings are made in accordance with the requirements of the War Office and Ministry of Aviation for use in explosives factories. For mounting several fittings together, with one or more associated cameras, the manufacturers also design and make mounting frames either in mobile form or for permanent installations. These are normally constructed in 2in diameter by 10 gauge steel tube and rolled steel sections.

[Reply Card No. 1452]

SHORTER REPORTS *(Continued)*

Research Development and Productivity Exhibition

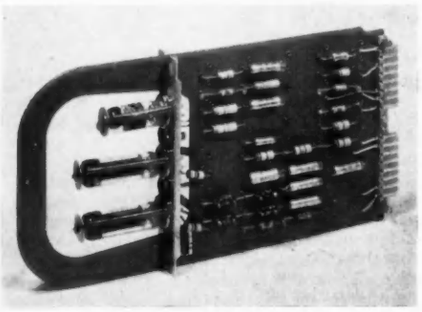
THE Birmingham Productivity Association, which is a voluntary organisation of all interested in increasing industrial productivity (directors of companies, managers, trade unionists and technical educationalists), announces that it is organising a special exhibition dealing with industrial research, development and productivity. It will be held in Bingley Hall, Birmingham, in May, 1962. The Department of Scientific and Industrial Research has booked a large central stand and will be supported by at least four other research associations whose activities are of interest to Birmingham industry. In addition, fourteen members of the Association have booked space and they intend to show how research has assisted them in the development and manufacture of their products. Exhibitors are not restricted to Midland firms.

In a section occupying the whole of one hall there will be demonstrated the great part which gas plays in modern industry. All kinds of equipment using gas will be installed under actual working conditions and visitors will be able to see many processes carried out in the exhibition. Conferences on various subjects will be held during the exhibition and a conference hall will be built within Bingley Hall for this purpose. At other times, films relating to research and productivity will be shown. The University of Birmingham, College of Advanced Technology and the Youth Employment Branch will be having stands to show the training which is offered to young men who are making an industrial career.

Further information is obtainable from E. H. Meekings, secretary, Birmingham Productivity Association, Chamber of Commerce House, 75, Harborne Road, Edgbaston, Birmingham, 15.

Copper-Clad Laminate for Printed Circuits

FOR high insulation resistance when wet, a laminate needs a high resin content, but this tends to make it brittle, and may impair the flexibility necessary if cold punching is to be undertaken. Where laminates are used for mass production of printed electrical wiring, however, it is desirable to avoid dimensional changes due to expansion and contraction caused by the hot punching process. A copper-clad industrial laminate, XXXP–1C, which can be punched at room temperature using conventional laminate punching tools, has therefore been produced by Formica Ltd., 84-86 Regent Street, London, W.1. We illustrate a plug-in circuit panel made



Plug-in circuit panel for "Pegasus" computer made in cold punching copper-clad laminate

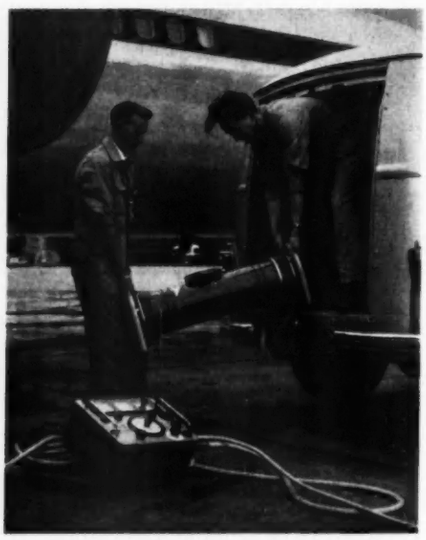
in this material for the Ferranti "Pegasus" computer. The properties of the material are stated to include low moisture absorption and good adhesion between the copper cladding and the base laminate. It is also highly resistant to blistering of the copper foil under the influence of hot solder, while the inherent flexibility of the base material corrects any tendency of the printed circuit to warp after soldering.

Another quality of the laminate is its resistance to chemical attack by the acid or alkaline cyanide solutions used in gold plating of plug-in contacts on printed circuit boards. Formica XXXP–1C is unaffected by mineral oils or by the trichloroethylene commonly used as a degreasing agent in the manufacture of printed circuits. The base material is made from a highly absorbent paper, which is impregnated with a phenolic resin, then consolidated and bonded with the copper cladding under controlled heat and pressure. The most common sheet size is 48in by 36in by $\frac{1}{16}$in (1210mm by 910mm by 1·57mm), clad on one or both sides with electrolytic copper foil of more than 99·5 per cent purity and 0·0015in (0·38mm) nominal thickness. Laminates from $\frac{1}{32}$in to $\frac{1}{8}$in (0·8mm to 3mm) in thickness, clad with copper foil up to 0·045in (1143mm thick, can be produced.

[Reply Card No. 1458]

Portable X-Ray Units

FOUR additions to the "Andrex" range of portable X-ray units are announced by the Industrial Division of Watson and Sons (Electro-Medical) Ltd., East Lane, North Wembley, Middx. We illustrate a 250kV, 6mA unit in which



Handling the 156 lb tubehead of a 250kV, 6mA portable X-ray unit

the weight of the tubehead has been reduced to 156 lb, over 100 lb less than the previous model. The beam angle is 60deg., enabling two 15in films to be taken at a focus/film distance of less than 30in. This feature, together with the 6mA tube current, means a substantial increase in footage of welding that can be radiographed in a day.

A 250kV/360 deg., 5mA unit has a tubehead weighing 153 lb and is suitable for the examination of circumferential welds in thicknesses of steel up to 2in. The 360 deg. band has an effective width of 40 deg. and a "forward throw." A lead belt with radiation port is provided which enables the unit to be used for directional work.

A third addition to the range is a 180kV, 8mA unit with a tubehead weighing 93 lb. The high tube current represents a considerable advance over earlier portable units. Beam angle is 60 deg. so that, as with the 250kV unit, the beam will cover two 15in films at a focus/film distance of less than 30in.

All three of these units have high duty cycles but embody water cooling coils to give 100 per cent duty cycles where required. Visual and audible warning devices can be incorporated to comply with the new regulations.

The fourth of the new "Andrex" units is a portable instrument covering the whole range of low kilovoltage radiography from 10 to 80kV. The tubehead weighs only 28 lb and incorporates the high-tension transformers and the beryllium window X-ray tube. Water cooling is an optional extra. Appropriate applications are aircraft radiography and, in particular, the examination of very thin aluminium for corrosion. It is also well suited for the critical examination of plastics, graphite and any kind of non-metallic material. The unit can also be used for steel up to about $\frac{1}{4}$in thickness. Automatic protection is provided against overheating of the tubehead and sudden variations in the mains supply.

[Reply Card No. 1420]

Nuclear Propulsion for Merchant Ships

FOLLOWING the announcement by the Minister of Transport on November 8 that the Government had decided to authorise a vigorous programme of research aimed at a reactor system which was economically attractive to a wide range of shipping, and that the programme would be carried out by the Atomic Energy Authority in conjunction with industry, a small working group has been set up to consider what the new programme of research into marine nuclear propulsion should contain and to keep progress under review.

The group, which had its first meeting on November 28, and will be known as the Working Group on Marine Reactor Research, is responsible jointly to the Minister for Science and the Minister of Transport and its terms of reference are : "To advise and make recommendations on the programme of research required to advance nuclear propulsion for merchant ships." It will advise the Ministers concerned but will not make a formal report. The chairman is the Permanent Secretary to the Ministry of Transport and its members are : Sir William Cook (Atomic Energy Authority), Sir Victor Shepheard (British Shipbuilding Research Association), Mr. A. Logan (General Council of British Shipping), Mr. H. N. Pemberton (Lloyd's Register of Shipping), and Professor J. Diamond of Manchester University, together with representatives of the Admiralty, the Office of the Minister for Science, and the Ministry of Transport.

"International Journal of Production Research"

THERE has just been issued by the Institute of Production Engineers the first edition of a new quarterly publication *The International Journal of Production Research*. This journal is designed to promote the advancement of scientific study of all factors which influence the production process and will cover production research in all technologies. It is stated in the first issue that the principal intention of the journal is to provide a vehicle for the publications of those university and other research workers whose primary interest is in advancing the science of production and for whom, until now, there has been no single and appropriate journal.

Professor N. A. Dudley, head of the Department of Engineering Production at the University of Birmingham, has been appointed the editor of the journal with two associate editors—Dr. E. N. Corlett and Dr. S. Eilon—and a panel of consulting editors, all of whom are authorities in production techniques, from this and a number of overseas countries. The managing editor is Miss M. S. C. Bremner, of the Institute of Production Engineers (10, Chesterfield Street, London, W.1), to whom all enquiries should be addressed.

Moulding of Pressure Vessels

PRESSURE vessels for rather high pressures at normal temperatures are frequently made from glass filaments rendered impermeable by a plastics matrix. An innovation, however, is the moulding of a pressure vessels from a single piece of plastics material, which has recently been demonstrated by Emerson Walker Ltd. The technique used is to blow a heated tube of the material out to conform with a female mould, and vessels made in this manner have withstood test pressures up to 200 lb per square inch. The new process has the advantage that vessels of arbitrary, and even re-entrant, shapes can be formed, that no welding is necessary, and that the vessel does not need any protective or decorative finish.

The process has been applied to a sample design in the form of a 7-gallon tank of irregular shape. Test pieces were blow moulded by the firm's Test and Development Department in low density polythene, high density polythene and polypropylene. The usual weight of these containers is 3 lb and this gives a normal wall thickness of about $\frac{1}{8}$in to $\frac{3}{16}$in. The test piece had a variety of curves which were designed to show up abnormal " thinning."

The containers using high density polythene have weighed from approximately $2\frac{1}{2}$ lb to approximately $5\frac{1}{2}$ lb on a number of different runs, these weight changes being obtained by altering the die on the tube extruder ; normal wall thicknesses have been from less than $\frac{1}{16}$in to approximately $\frac{1}{4}$in for the different containers.

Using low density polythene the test piece has varied in weight from less than 10 oz to about $3\frac{1}{2}$ lb and the normal wall thickness has varied from 0·017in to approximately $\frac{3}{16}$in ; the thin walled specimens were blown for use as liners. The liners were found to be thick on top and on the bottom.

Amongst the many evaluations which these samples underwent is a hydrostatic bursting experiment ; this test is used to determine whether the sample has been blown correctly, that the correct temperatures have been used and that adequate mould locking force is available to suppress flashes at the top and bottom of the test piece.

Standard high density polythene test pieces weighing approximately $5\frac{1}{2}$ lb have a bursting pressure between 160 lb per square inch and 200 lb per square inch, and in every case the first leak or tear has occurred elsewhere than near or on the line of the joint in the mould.

The test pieces were made in natural colours to facilitate inspection for flaws, lesions and other irregularities in the finished blow moulding. This visual inspection is particularly useful with polypropylene test pieces because if the natural polypropylene is mishandled, i.e. too high an extrusion temperature or sudden chilling, this shows up as a variation in the opacity or translucency of the finished polypropylene test piece. In the case of polypropylene, which is used in the pharmaceutical, cosmetic and food industries in the form of containers, pipe fittings, pump casings, &c., correct processing is very important.

The Test and Development Department of Emerson Walker Ltd. is doing additional work on thin-walled containers and liners. It is expected that normal wall thicknesses for liners will reach 0·010in using low density polythene ; conversely, using high density polythene or polypropylene very thick walled test items will be made with a view to the manufacture of pressure vessels and pump casings withstanding initially up to 500 lb per square inch. Current development tests are being undertaken with ABS polymers and excellent impact and pressure values are expected.

[Reply Card No. 1470]

Body finishing line with trucks of marshalling conveyor on the left

Speeding Car Body Assembly

A NEW system of marshalling components on the body assembly lines for the Austin A40 and 850 bodies introduced at the Longbridge works of the British Motor Corporation Ltd., nearly two years ago has proved so successful that it has been adopted for a new car assembly building now under construction. Prior to the introduction of the new system it had been the general practice to deliver components—such as screens, bumpers, lamps, instrument panels, &c.— from the stores on trucks and to put them on the floor in pallets adjoining the assembly line. Under the improved system there has been installed alongside the assembly line a separate floor-level conveyor which moves at the same speed and carries two trucks for each body undergoing assembly. Each pair of trucks is loaded with a complete set of components for a vehicle in the main stores and when it is linked on the conveyor by the assembly line it moves along with a vehicle so that parts are immediately to hand for the operatives in the required order.

The assembly line with its feeder truck conveyor can be seen in the photograph we reproduce. Its installation has resulted in a reduction of damage to components, space has been saved and a greater degree of flexibility in organisation of production has been made possible. Production time has been saved as operatives do not have to move far to get parts and by giving a closer measure of stock control there is no longer any need for travelling to the stores to fetch further supplies in the event of a pallet stock being exhausted.

Small Humidifier and Air Purifier

WE learn that Hygro-Robot Ltd. has introduced a new thermoplastic " H-R " humidifier and air purifier for centrally-heated rooms. The unit, designed to counteract excessive dryness, has a capacity sufficient for enclosed rooms up to about 1800 cubic feet and measures $19\frac{1}{16}$in in length by $13\frac{3}{4}$in high by $2\frac{3}{4}$in depth, the water container having a capacity of 4 pints. Depending upon temperature and relative humidity, the humidifier will evaporate from 1 to 4 pints per day and since it contains no spray jets this humidity will stay in the air. The evaporation rate is automatically adjusted to the prevailing conditions so that in centrally-heated rooms a balanced condition of comfort is maintained. Special treatment is given to the filter-evaporator elements to ensure that they are hygienic and chemically clean, and the filters attract and absorb dust, dirt and fumes from radiators, so that the hot air is washed and cleaned before being passed into the room. There are no moving parts, the unit consisting of a water container, grille cover, radiator mounting hooks, and a filter, which should be replaced at intervals of about five to six weeks.

[Reply Card No. 1471]

Machine Tool Design Scholarship

A PLAN to sponsor advanced specialised education in machine tool design was announced early in 1959 by the Machine Tool Trades Association, and subsequently six firms released a total of nine students for the first course. The scheme provides a two-year full-time course, of post-graduate standard, at Manchester College of Science and Technology, and the nine students, who recently completed the first course, have all qualified for the award of the college diploma and the associateship of the College (A.M.C.S.T.).

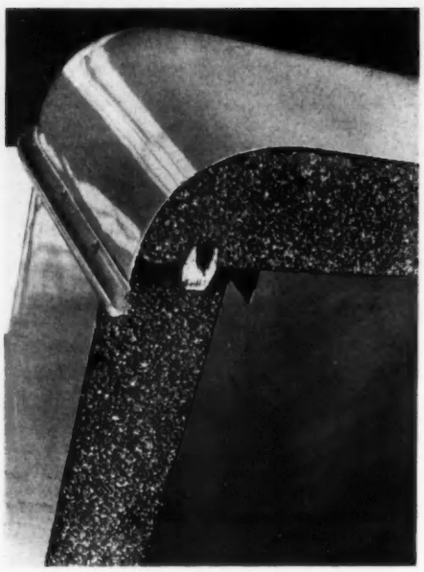
In addition to their studies at the university, the students spend their vacations upon projects in industrial fields different from their previous experience. The members of the group which has just graduated also took advantage of opportunities during such periods to work in the factories of continental machine tool manufacturers. Under the scheme seven students were entered by firms in 1960, and for the 1961 course that has just started, thirteen students were selected.

Three sample 7-gallon containers blow moulded by Emerson Walker Ltd. using different thermoplastic materials : (left to right) low density polythene (I.C.I.), high density polythene (British Resin Products) and polypropylene (Shell Chemical). The containers weigh approximately 3 lb with a wall thickness from $\frac{1}{8}$in to $\frac{3}{16}$in: the flange around the port is the size of the tube from which the tanks were blown

SHORTER REPORTS *(Continued)*

Load-Bearing Insulating Sandwich

FOR the construction of refrigerated and insulated bodies for road vehicles, in which the weight of the body shell is important, Mann Egerton Company Ltd. has evolved a technique in which the insulation serves to stabilise the skin and no body framework is needed. The insulating medium is "Plasticell," a high strength, lightweight, closed cell expanded



Section of a corner of the roof of a body using the insulation to stabilise the stressed skin. The sandwich is bonded with CIBA "Araldite"

polyvinyl chloride manufactured by Microcell Ltd. The plastic, which has a density of 2·5 lb. per cubic foot and a compression strength of 40 lb. per square inch, is used in 3½in thick slabs bonded with "Araldite" to sheets of 20g aluminium to form structural sandwich panels. This form of construction has been applied to a refrigerated body on a 30 cwt Thames "Trader," in which case the reduction in unladen weight was no less than 5 cwt, a large proportion of the disposable load. Despite the relatively exotic materials used, the construction is so much more rapid that the production costs are reduced.

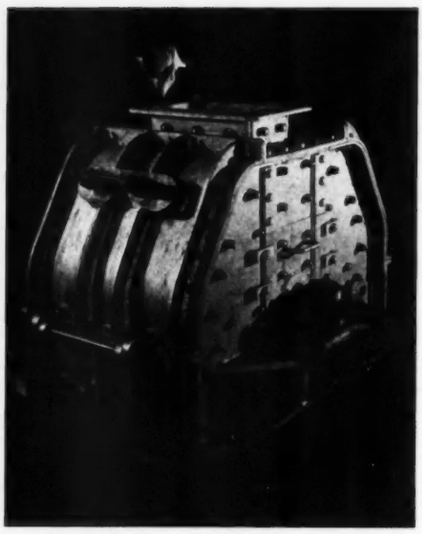
[Reply Card No. 1447]

Reversible Impactors

A RANGE of reversible impactors with capacities of up to 1500 tons per hour is now being manufactured at the Fraser and Chalmers Works of G.E.C. (Engineering) Ltd. at Erith, Kent. These "Pennsylvania" design crushers, the first of their type to be made in the United Kingdom, are suitable for use in the refractory, metallurgical, lime, cement, gypsum and quarry industries. The reversible rotor of this design of impactor is used with breaker blocks fitted on both sides of the machine and the feed chute placed directly over the centre of the rotor. The impactor is thus effective when its rotor is driven in either direction and by systematic reversal it is possible to balance wear between the two sets of breaker blocks and between the two faces of each hammer. This is stated to reduce the maintenance costs involved with a non-reversible design impactor, which has to be dismantled before its hammers can be reversed.

Two types of heavy-duty impactor are available, one having adjustable breaker blocks and the other with fixed blocks.

The frames of these impactors, one of which we illustrate, comprise a welded assembly of heavy steel sections and plates fitted with



Reversible impactor in course of assembly at maker's works

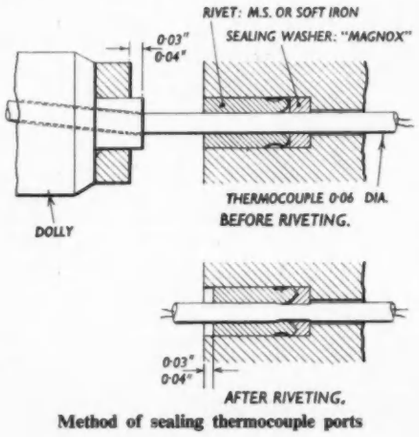
replaceable wear-resistant liners. Their breaker blocks are mounted on hinged covers which, after unbolting, can be swung away from the rotor to give complete freedom of access to the inside of the machine. The rotor comprises a series of spaced discs, keyed on to the shaft, with the wear resisting steel hammers held in the spaces by suspension bars. The number of discs and hammers depends on the duty and capacity of the crusher. Self-aligning spherical roller bearings support the shaft. The breaker blocks are shaped to give a cubical product at a high rate of reduction with minimum wear. On the machine fitted with individually adjustable breaker blocks, as their faces wear the blocks can be moved towards the hammer circle to ensure a constant tonnage output of a uniform size of product.

A direct-coupled motor is the normal driving system employed for these impactors but a fluid drive or multiple vee-belts can be fitted as alternatives. Variable speed control is possible with a direct-coupled motor or a fluid drive.

[Reply Card No. 1446]

Hollow Sealing Rivets

WE are informed that King Aircraft Corporation (a division of H. K. Porter Company (Great Britain) Ltd.), in the course of its work for the U.K.A.E.A. and the reactor industry, has developed a thermocouple-port hollow sealing rivet for applications where a thermocouple passes through the cap or wall of a pressure vessel.



Method of sealing thermocouple ports

Our illustration shows the rivet, together with a "Magnox" sealing washer, before and after crushing with the special riveting dolly which controls the depth of crush. It will be seen that as the rivet is crushed in the port the "Magnox" washer is deformed and seals itself against the walls of the port and also on the thermocouple. At the same time the rivet itself, made from soft iron, seals into the walls of the port and the bore collapses and seals against the thermocouple.

The dolly, it will be seen, is pierced at a slight angle so that the thermocouple lead is not in the way of the striker.

Twenty-four 0·060in diameter, two-core stainless-steel-sheathed thermocouples have been sealed, pitched at 0·275in centres, and all twenty-four were pressure tight on first testing at 300 lb per square inch at room temperature and were still satisfactory at 400 deg. Cent.

The sealing of thermocouples passing through pressure vessels has created problems with "in-pile" applications as brazing is incompatible and any welding near the thermocouples breaks down the insulation, but this new method, for which patent protection has been applied, should prove of interest and value to nuclear engineers.

[Reply Card No. 1445]

Space Heater

WE illustrate below an improved model of the "Silent Glow" space heater made by Contractors and Industrial Equipment Ltd., 31, Buckingham Street, Oldbury, Birmingham. This heater is designed for a wide range of applications where a steady flow of warm air is required for drying and heating purposes and, as shown in the photograph, is adaptable for de-freezing vehicles or tractors.

The heater, which weighs only 46 lb dry, is driven by a fractional horse power motor and,

Oil-burning portable heater used to direct a stream of hot air when de-freezing vehicles

when filled, only needs to be coupled to a mains supply for operation. Its tank holds 5 gallons of fuel and the normal consumption of the burner is stated to be 3 pints an hour when giving a heat output of up to 72,000 B.Th.U. When switching on, ignition of the oil burner is automatic and a thermostatic control incorporated is designed to keep the motor running to cool the heater after switching off and eliminate danger of spontaneous ignition. The two hinged carrying handles can be used to position the heater to direct the stream of heated air at any required angle.

[Reply Card No. 1455]

High Pressure Micro-Manometer

By J. LOCKEY, M.Sc., A.M.I.Mech.E.* and N. MAW, B.Sc. A.M.I.Mech.E.†

In the course of a programme of work being carried out in the Engineering Department of Sunderland Technical College, need was found for a fundamental micro-manometer suitable for the measurement of gas pressure differences of up to 2in of manometer fluid at pressures exceeding 1000 lb per square inch. The instrument illustrated in Figs. 1 and 2 was developed accordingly, and by means of it reproducible results have been obtained without undue manipulative difficulty.

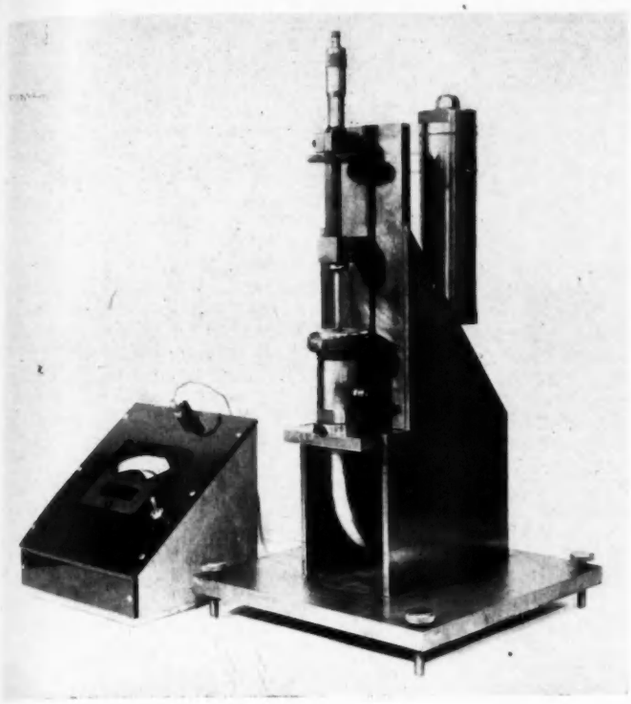


Fig. 1

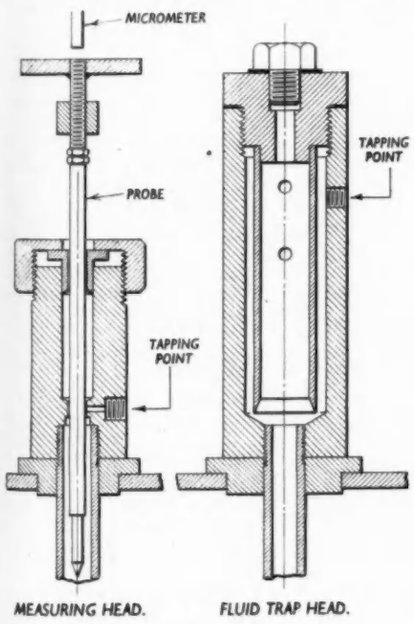


Fig. 2

The main " U "-tube is formed of solid drawn stainless steel tube, one limb terminating in a trap for the manometer fluid and the other limb carrying a measuring head. The level of the fluid in the manometer is located by screwing down an electrically-insulated probe which passes through a gland in the measuring head. Contact is indicated by the closure of a low voltage circuit, and the vertical displacement of the probe is measured by means of a micrometer. To obviate electrolysis at the point of probe contact the current is kept to a minimum by incorporating an indicating voltmeter in series with the probe and by using an a.c. supply.

The choice of a manometer fluid is governed by such factors as the magnitude of the pressure differential to be measured, the ability of the fluid to conduct electricity and its chemical stability. Normally mercury will fulfill these requirements, although greater sensitivity is obtainable if a less dense fluid is used as the base of an electrolyte.

Differential pressure head can be measured to an accuracy of 0·001in.

*Senior Lecturer, Engineering Department, Sunderland Technical College.
† Lecturer, Engineering Department, Sunderland Technical College.

Process Stage and Fault Recorder

Charts giving a timed record of the ocurrence and duration of the various stages of production processes, together with information on fault signals and their acknowledgment, are produced by the Le Boeuf recorder which has been introduced into this country by D. Robinson and Co. Ltd., 5 and 7, Church Road, Richmond, Surrey. The recorder is operated by signals derived from transducers in various parts of the systems being monitored. These are fed to an input unit consisting of ten plug-in modules, each controlling six recorder channels. An incoming signal, often of a fleeting nature, operates a sensitive moving coil relay which causes a capacitor to discharge through a resistance. In this way, even for the briefest input, a signal of sufficient duration to ensure a satisfactory mark on the chart is applied to the recorder. If an input is maintained, the resistance-capacitor combination acts as a smoothing circuit to minimise serrations in the recorded line.

The signal from each channel of the input unit is applied to the corresponding stylus in the recorder. These rest against a thin metallic film on the chart, and when a stylus is energised current flows from it, through the film, to a common graphite roller. The film will evaporate under the stylus, where the current is of greatest density, leaving a dark translucent mark on the chart. If the chart is stationary, this will be a round mark and the current will soon stop flowing due to lack of continuity. but if the chart is moving a continuous line will be recorded. The chart moves only on receipt of an input signal, a time marking being made simultaneously. Time is also recorded when the attendant presses an " accept " button to acknowledge an abnormal indication, and midnight is recorded automatically. When a signal is being received, a timebase is printed in one margin of the chart so that the exact time of any further signal can be read off by reference to the time recorded for commencement of the preceding one. Time markings are derived from a master clock which operates electro-mechanical counting relays.

The recorder is provided with three visual alarms and terminals for an audible alarm. Sections of chart may be removed by operating a cutting handle on the case while the device is in action, the chart not being stopped for longer than one-tenth of a second. Being translucent, the chart can be photocopied. The whole system normally operates on d.c. from a 48V battery or a transformer-rectifier unit.

[Reply Card No. 1453]

Automatic Sound Picture Viewer

Introduced by Spectro Ltd., Vale Road, Windsor, the " Salesmate " portable projector, takes loops of 35mm film and a tape, and projects a series of still pictures, accompanied by a spoken commentary, on to a screen 9in by 12in which can be viewed in daylight. The projector is completely self-contained and when closed is in the form of a suitcase 17in by 13½in by 6in. It is only necessary to plug the projector into a 240V, 50 c/s a.c. electric supply, and press a switch on the casing. The pictures and commentary are then shown automatically and the projector switches itself off at the end of the programme. As the film and tape are in loop form, rewinding is unnecessary and the projector is ready for re-use as soon as required. Transistors are used in the projector, which therefore needs no warming-up period, and will start to work immediately the switch is pressed.

It will take programmes of lengths from thirty-one to 150 frames, running from 1½ to eighteen minutes. Adjustment is provided for the length of dwell at each frame, and it is possible, by means of a separate switch, to hold one frame indefinitely ; when this control is operated the tape recording is switched off automatically while the frame is held. The power consumption is 450W. Special models are available for electric supplies other than the standard British 240V d.c.

[Reply Card No. 1451]

Lightweight Traction Motors

A third series of British Railways Type 2 diesel-electric locomotives with 1250 h.p. Sulzer 6LDA28-B intercooled engines is under construction. This engine has been used previously in twenty-five locomotives built by British Railways at Darlington, with A.E.I. electrical equipment, and in sixty-nine locomotives built by the Birmingham Railway Carriage and Wagon Company Ltd., which have G.E.C. electrical equipment, as described in The Engineer of October 27, 1961, page 700. The new series consists of fifty-seven locomotives to be built in the Derby and Darlington works of British Railways and to be supplied with power equipments, including the Sulzer diesel engines, by Associated Electrical Industries Ltd. (The Engineer, November 24, 1961, page 933). These locomotives will incorporate a new lightweight traction motor of 360 h.p., the 253AY, which will be manufactured in the A.E.I. works at Altercliffe Common and Greenland Road, Sheffield. Having the same horsepower as those in the Darlington-built 1250 h.p. series, but with reduced size and weight, it will enable economies to be realised in the cost and construction of the locomotives. A re-design of the cab structure has been facilitated, together with modifications to other mechanical parts. In addition, an increase of starting tractive effort from 40,000 lb to 45,000 lb has been obtained. The transmission, with a gear ratio of 18/67, will incorporate A.E.I. resilient gears. The motor assists in continuing the process of weight reduction in Type 2 locomotives which began in some earlier Darlington-built units with the 1160 h.p. (non-intercooled) Sulzer 6LDA28 engine by omission of the separate exacter from the electrical equipment (The Engineer, January 29, 1960, page 192).

INDUSTRIAL NEWS

Wages and Hours

Although the " pay pause " has now been in operation for a few months, figures issued by the Ministry of Labour last week showing changes in rates of wages and hours of work for January to October, 1961, do not show signs of the " pause " when compared with the corresponding period of last year. In the first ten months of 1961, approximately 7,639,000 workers received an aggregate increase of approximately £3,894,000 in their full-time weekly rates of wages, whilst some 5,631,000 workers received an aggregate reduction estimated at 11,017,000 hours in normal weekly hours of work. In the corresponding months of 1960, the Ministry states, 8,480,000 workers had a net increase of £2,990,000 in their full-time weekly rates of wages, and 6,440,000 workers had an aggregate reduction of 11,840,000 hours in their normal weekly hours of work.

Estimates of the effect of reported changes in rates of wages and hours of work coming into operation in the United Kingdom during October, the Ministry states, indicate that about 1,625,000 workers received an aggregate increase of approximately £835,000 in their full-time weekly rates of wages, and about 1,080,000 workers had their normal weekly hours reduced by an average of two hours.

T.U.C. and the National Economic Development Council

The current issue of the *Bulletin* of the British Employers' Confederation comments upon the T.U.C's refusal, at least for the time being, to join the Chanceller of the Exchequer's planning body, the National Economic Development Council (THE ENGINEER, October 6, 1961). The suggestion is, the *Bulletin* states, that the T.U.C. will persist in its refusal unless the " pay pause " is called off or unless a termination date is given that is acceptable to the T.U.C.

In the face of the unhappy position in the electricity supply industry the Prime Minister and the Chancellor have both made it clear that the Government will use all the powers it possesses, the *Bulletin* says, direct or persuasive, to keep the " pause " in being as the only right short-term treatment for Britain's economic ills. It is to be hoped, the *Bulletin* adds that while the treatment is continuing the planning body will at least be set up to begin considering long-term remedies.

The Confederation points out that national productivity has not increased to an extent which would enable the big increases in wage costs over the past twelve months to be absorbed, and adds that no general increase in pay can possibly be justified by current economic achievements.

The willing co-operation of the T.U.C. is needed, the Confederation says, if Britain is to derive the fullest advantage from the planing body. Although the new body can do useful work without T.U.C. co-operation, its deliberations and its effectiveness would suffer by the absence of T.U.C. representatives. The price the T.U.C. is demanding for co-operation, however, is an impossible one, the Confederation states, and a more far-sighted view for it to have taken would have been that—pause or no pause—a fully representative planning body might make some real progress in avoiding the very evil which the unions should be most anxious to avoid in the interests of their members, namely, further damage to Britain's prosperity and standards of living by loss of competitive power.

Lloyd's Statistical Tables

Lloyds Register of Shipping has published its *Statistical Tables* 1961, which are based on ships entered in Lloyd's Register Book as published in July. The table show that the world tonnage increased by 6,146,000 tons compared with 1960, the amount being 135,916,000 tons gross which includes the U.S.A. reserve fleet estimated at 12,500,000 tons gross. The principal merchant fleets are in Great Britain and Northern Ireland 21,465,000 tons ; U.S.A. 24,613,000 ; Norway 12,025,000 tons ; Liberia 10,930,000 tons ; Japan 7,954,000 tons ; Greece 5,439,000 tons ; and Italy 5,319,000 tons. Compared with 1960 Norway has moved back into third place, and Greece has risen from tenth to sixth position. Since 1960 the total of oil tankers has risen by 2,384,000 tons to 43,849,000 tons gross, representing 32·3 per cent of the total tonnages, and the following are the totals of the main national fleets : Great Britain and Northern Ireland 7,293,000 tons ; Liberia 7,015,000 tons ; Norway 6,701,000 tons ; and U.S.A. 4,675,000 tons. Laid-up tonnage is estimated at 2,500,000 tons compared with 5,000,000 tons last year and 9,000,000 tons in 1959. Of the fleet of Great Britain and Northern Ireland 33 per cent is under five years old, and 54·7 per cent under ten years old, the corresponding figures for the world fleet being 29·8 per cent and 48·9 per cent. The table setting out the propulsion analysis shows that of the tonnage owned in Great Britain and Northern Ireland 2,824,647 tons was propelled by reciprocating machinery, 7,760,074 tons by turbines, and 10,878,165 tons by diesel engines ; the corresponding figures relating to world tonnage being 30,781,665 tons, 43,475,122 tons, and 61,496,502 tons respectively. The merchant ships entered in the Register Book to the Society's classification in July, totalled 11,149 of 55,826,000 tons gross.

Industrial Disputes

The number of stoppages of work due to industrial disputes in the United Kingdom, beginning in October, which came to the notice of the Ministry of Labour, was 246. In addition twenty-six stoppages which began before October were still in progress at the beginning of the month. The approximate number of workers involved during the month at the establishments where these 272 stoppages occurred, the Ministry says, has been estimated at 72,100, this total including 17,800 workers involved in stoppages which had continued from the previous month. Of the 54,300 workers involved in stoppages which began in October, the Ministry states, 49,100 were directly involved and 5200 indirectly involved. The aggregate of 376,000 working days lost during October included 231,000 days lost through stoppages continued from the previous month.

In the engineering industry there were twenty-four stoppages in progress during October, involving 5600 workers and a loss of 21,000 working days. In the metal manufacturing group 16,100 workers took part in twelve stoppages which resulted in a loss of 192,000 working days. Some 8700 workers were involved in thirteen stoppages in the motor vehicle and cycle group during the month, which resulted in the loss of 31,000 working days, whilst 75,000 days were lost by 11,900 workers involved in thirty-nine stoppages in the construction industries. There were 134 stoppages in coal mining in October which involved 20,100 workers and resulted in 35,000 working days being lost.

In the first ten months of 1961 there have been 2355 stoppages including 707,000 workers and a loss of 2,798,000 working days.

Apprentices in the Construction Industries

The Ministry of Works announces that preliminary estimates, based on the census undertaken in September of the number of apprentices employed in the construction industries in Great Britain, show that the number of boys with written indentures has fallen to 37,100 compared with 39,200 in September, 1960. The number of boys with verbal agreements remains much the same, 45,900 in September this year as against 45,800 last year. The intake of new boys is still lower than the intake five years ago and wastage may be high.

On the other hand, the Ministry says, figures provided by the National Joint Council showing the number of boys registering as apprentices in Great Britain, although not strictly comparable with these figures indicate that the position has been improving recently. In 1960 some 10,100 boys registered as apprentices, compared with 8000 in 1959 and 8400 in 1958. In the first nine months of 1961, 6900 boys have registered.

The census figures showed a drop of 16,000 in the number of craftsmen, including apprentices, employed in Great Britain, from 681,000 in September, 1960, to 665,000 in September, 1961, despite an increase in the total labour force of 20,000.

Export Trends

Recent export trends are evaluated in the November issue of the Treasury's *Bulletin for Industry*. Last year, the Treasury states, United Kingdom exports of manufactures were 38 per cent larger by value than in 1954, whilst exports by the rest of the world were 85 per cent larger. The unfavourable comparison holds for each year between. From the analysis contained in the *Bulletin*, it is clear, the Treasury says, that the growth of United Kingdom exports has been hindered by certain structural features of its trade. The most important of these, the Treasury suggests, is probably dependence on sterling area markets, where demand has been growing relatively slowly and competition has sharpened to the United Kingdom's disadvantage. This is not to say that United Kingdom exports to the sterling area have ceased to offer opportunities for growth, the Treasury adds, but it underlines the need to move forward energetically in these markets with a wide range of products.

PERSONAL AND BUSINESS

Appointments

THE LAMBRETTA/TROJAN GROUP OF COMPANIES announces the appointment to the board of Trojan Ltd. of Mr. J. M. West as sales director.

MR. W. CROSSLAND has been appointed director and general manager of Uni-Tubes Ltd., and of its subsidiary company, Portland Plastics Ltd.

MR. J SINGLETON-GREEN, M.I.C.E., M.I.Struct.E., F.Inst.H.E., has joined Messrs. S. P. Christie and Partners, consulting engineers as a consultant.

MR. E. R. HENSCHKER, A.M.I.Mech.E. and MR. R. M. L. ELKAN, A.M.I.Mech.E., have been appointed directors of the Loewy Engineering Company Ltd.

MR. VERNON H. WILLEY has been appointed by Firth Cleveland Steel Ltd., to a special post with the company as marketing manager—stainless steels.

MONSANTO CHEMICALS LTD. announces that Sir William Garrett has retired after twenty-six years as a director of the company. Mr. J. M. Kershaw has been appointed to the board.

MR. FRANK KENYON, a senior director of the William Kenyon group of companies, has been elected chairman of the Federation of European Petroleum Equipment Manufacturers.

THORN ELECTRICAL INDUSTRIES LTD. announces that Mr. G. D. Sparrow, M.I.Prod.E., general manager of its mechanical and works engineering departments, has been appointed to the board of Atlas Lighting Ltd.

MR. A. J. ELLIS, general works manager, MR. J. CAPELING, works manager, fluorescent fittings division, and MR. T. P. METCALFE, financial controller, have been appointed to the board of Smart and Brown (Engineers) Ltd.

MR. JAMES JACK, previously financial director of Dorman Long and Co. Ltd., has been appointed managing director—Group finance and administration. Mr. Thomas Young has been appointed secretary of the company.

THE PERKINS GROUP, Peterborough states that Mr. N. M. F. Vulliamy, A.M.I.Mech.E., has been appointed chief engineer (diesel); and has been succeeded as manager of the Group's experimental department by Mr. A. M. Porkess, A.M.I.Mech.E.

MR. FOSTER M. STEWART has announced his retirement from the position as managing director of The North British Rubber Company with effect from December 31. He remains a member of the board. Mr. E. A. Martin, works director, will succeed Mr. Stewart as managing director.

THE NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE announces the appointment of Dr. J. Howlett as head of its "Atlas" Computer Laboratory. The laboratory, to be built adjacent to the Institute's Rutherford High Energy Laboratory at Harwell, will house an "Atlas" electronic digital computer.

THE INSTITUTION OF CIVIL ENGINEERS announces that Dr. M. F. Kaplan has been appointed research director of the Civil Engineering Research Council in London. He will take up his appointment in February. Dr. Kaplan is at present Head of the Civil Engineering Division of the Council for Scientific and Industrial Research in South Africa.

MR. LINDSAY HUNTING is retiring from the chairmanship of the Hunting Group as from the end of the year. The new chairman will be Mr. Pat (C. P. M.) Hunting, the present vice-chairman, and son of Sir Percy Hunting, himself a former chairman of the Group. The new vice-chairman will be Mr. Clive (L. C.) Hunting, eldest son of Mr. Lindsay Hunting.

ASSOCIATED ELECTRICAL INDUSTRIES LTD. states that Dr. J. R. Mortlock, M.I.E.E., has been appointed assistant chief engineer (engineering services), A.E.I. (Manchester) Ltd. He retains his position as chief engineer, A.E.I. systems engineering department. Mr. D. M. Paterson has been appointed assistant superintendent, large industrial machines department, A.E.I. motor and control gear division.

Business Announcements

I.V. PRESSURE CONTROLLERS LTD., 683, London Road, Isleworth, Middlesex, is now manufacturing under licence in the United Kingdom, the Gestra Duo steam trap type BK 15.

BRITISH INSULATED CALLENDER'S CABLES Ltd. announces that its Luton branch has moved to new and larger premises at Cradock Road, Skimpot Road, Luton, Beds. (telephone, Luton 52484).

W. BRYAN SAVAGE LTD. has closed its offices at 17, Stratton Street, London, W.1, in order to transfer its sales department to Westmoreland Road, Colindale, London, N.W.9 (telephone, COLindale 7131).

WILKES BERGER ENGINEERING COMPANY LTD. announces that it has acquired the whole of the issued Ordinary and Preference share capital of The Premier Spring Company Ltd., Redditch, Worcs.

BLAW KNOX LTD. has announced that, with effect from December 1, 1961, its construction equipment division will be located at the Division's new headquarters at Short's Way, Rochester, Kent (telephone, Chatham 41041).

COCHRAN AND CO., ANNAN, LTD. has acquired from L. and C. Steinmuller, Summersbach, Germany, the exclusive United Kingdom manufacturing rights for the Steinmuller system of evaporative cooling as applied to open hearth, re-heating and various other types of furnaces.

THE ROYAL AIRCRAFT ESTABLISHMENT, Farnborough, will shortly take delivery of a P.B. 250 computer, manufactured in Los Angeles by Packard-Bell Computer Corporation but sold and installed by its English agent, Benson-Lehner (G.B.) Ltd., West Quay Road, Southampton.

JOHN I. THORNYCROFT AND CO. LTD., announces that Mr. H. C. Johnson, general publicity manager, will retire on December 31 after forty-seven years service with the company, and that from January 1, 1962, Mr. J. G. Gunson will be in control of the advertising section while Mr. R. T. Mason will deal with Press and Public Relations.

MR. A. E. THORNTON, A.F.R.Ae.S., special director and foundry general manager of Firth-Vickers Stainless Steels Ltd. is, on medical advice and at his own request, retiring from the service of the company on December 31, 1961, after forty-five years with the company and its parent company, Thos. Firth and John Brown Ltd.

THE BRITISH INSURANCE (ATOMIC ENERGY) COMMITTEE announces that it has completed negotiations with the Central Electricity Generating Board for the insurance of the three nuclear power stations at Berkeley, Bradwell and Hinkley Point. The insurances on the first two stations are already in effect: the Hinkley Point insurances will apply from the date on which loading of the first reactor commences.

MIRRLEES, BICKERTON AND DAY LTD., states that as from January 1, 1962, it will change its name to Mirrlees National Ltd., and with effect from the same date the undertakings of the National Gas and Oil Engine Company Ltd., Ashton-under-Lyne, Lancashire, will be transferred to the re-named company Mirrlees National Ltd. The activities carried on at the premises of the National Gas and Oil Engine Company Ltd. will continue, but all accounts and communications in respect of services and supplies for the Ashton works should be addressed to Mirrlees National Ltd., Hazel Grove, Stockport, Cheshire. All correspondence and orders for spare parts for both factories should be addressed to Mirrlees National Ltd., Spare Parts Division, National Works, Ashton-under-Lyne.

Contracts

PARSONS MARINE TURBINE COMPANY LTD., a member of the Richardsons Westgarth Group, has received from Vickers-Armstrongs (Shipbuilders) Ltd., the order to construct and install the turbine propulsion machinery for a guided missile destroyer.

SWAN, HUNTER AND WIGHAM RICHARDSON LTD. announces the order for two cargo ships to be built for the Nigerian National Line of Lagos. Each ship is to carry a deadweight of 9500 tons, and will have a service speed of 15 knots and be powered by a Sulzer diesel engine.

BLAW KNOX LTD. and W. W. BROWN AND PARTNERS LTD. jointly announce receipt of an order from Rockware Glass Company Ltd. of Greenford, Middx., for designing and supplying a new glass batch-mixing plant at an approximate cost of £200,000. The new plant provides for the complete mechanisation of raw materials handling, storage, batching and mixing.

MITCHELL CONSTRUCTION COMPANY LTD., Peterborough, has been awarded a further contract, valued in the region of £275,000, by the Midlands Project Group of the Central Electricity Generating Board for the construction of workshop and office block for Drakelow "C" Power Station at Burton-on-Trent. This contract brings the total value of work on hand by the Mitchell Construction Company at Drakelow "C" Power Station to approximately £1,475,000. Work on the new contract will commence this month and is estimated for completion in December, 1963. The consulting engineers are L. G. Mouchel and Partners.

DRYSDALE AND CO. LTD. are to supply the dewatering pumps for the new Clyde dry dock, their duty being to empty the dock of 40,000,000 gallons of water in under two and a half hours. Three electrically-driven axial flow pumps of 60in bore with a combined capacity of 255,000 gallons per minute will be provided. The contract also includes drainage, boosting and ballasting pumps.

Miscellaneous

S.B.A.C. DISPLAYS.—The Society of British Aircraft Constructors will hold Displays in 1962—from September 3 to 9—and in 1964.

DYNAMIC BEHAVIOUR OF PNEUMATIC GAUGING SYSTEMS.—Three errors of some significance occurred in our printing of this article in our issue of November 24, 1961. Equation (iii) on page 879 should have read $Q_o = c_o k_n a_o (P - p)_\alpha$ and not $Q = c_o k_n a_o (P - p^\alpha)$ as printed. On page 880 about halfway down the first column K should have been in upper case (as defined by the expression following Equation (viii) in the formulas $\tan r = -\omega/K$ and $R = \left(\frac{1}{1+\omega^2/K^2}\right)^{\frac{1}{2}}$

TRACK-RIDING GROUND EFFECT MACHINE.—Hovercraft Development Ltd., the National Research Development Corporation subisidiary exploiting the "Hovercraft" principle of Mr. C. Cockerell, has announced that in addition to its work on jet-sheet containment cushioncraft, it is designing a large vehicle to ride on air bearings on a special track at speeds up to 300 m.p.h. The feasibility of such vehicles was demonstrated by Ford Motor Company in 1958, and the name "Levacar" devised for carriages employing levitation as distinct from orthodox flight.

P.V.C. STEELWORKS PIPING.—At the Motherwell plant of Colvilles Ltd., water to be cooled has been carried, in the past, by metal pipes which had a life of five years. For the new cooling plant at No. 2 Plate Mill development 10in diameter pipe in high impact P.V.C. has been installed together with sprinklers in the same material The pipe and fittings, manufactured by Extrudex Ltd., are light in weight, and the material, which is exceptionally strong, is high impact P.V.C. compound produced by British Geon Ltd.

MOTOR VEHICLE EXPORT.—The November, 1961, *Monthly Statistical Review* of the Society of Motor Manufacturers and Traders Ltd. includes details of the exports of the principal producing countries during the first six months of 1961. The United Kingdom was the largest exporter of commercial vehicles with 93,781; this is an unusual result, the figures for the first three months having shown, as usual, the United States of America as the largest. Also a new result, this country was only the third largest exporter of cars, with 178,891 (W. Germany 491,333, France 197,015). Of the countries outside the Commonwealth and Empire with imports numbering over 1000, Britain was the principal supplier to Eire and the Sudan, and of commercial vehicles only, to Finland and Portugal.

OIL SPILL BOOMS.—William Warne and Co. Ltd. has recently completed the installation of a Warne Oil Spill Boom to protect the oil basin at Dunkerque harbour. The boom which is manufactured from Du Pont Neoprene reinforced with synthetic fibre is moved in rafted form on one side of the harbour with the 50ft sections lying in concertina fashion. When the alarm is given an electric winch, on a dolphin on the opposite side of the harbour, by means of a cable lying on the harbour bed pulls the boom across the 650ft wide entrance to seal the gap. Through the medium of a special hose on top of the boom a water curtain can be provided to protect the boom against burning oil. Oil spill booms of this design are to be installed at the ocean berths at the Fawley Refinery of the Esso Petroleum Company Ltd.

Death

WE regret to record the death, at the age of sixty-five, of Mr. W. H. Heron, group works engineering director of Raleigh Industries Ltd. Mr. Heron had been with the company for forty years, and had risen from the ranks to become works engineer in 1943, a director of the Robin Hood Cycle Company Ltd. in 1951, and of Rudge-Whitworth Ltd. and the Triumph Cycle Company Ltd. in 1955. In 1956 he was also appointed to the board of the Raleigh Cycle Company Ltd.

CONTINENTAL AFFAIRS

by Our Continental Editor

Cable Layer "Marcel Bayard"

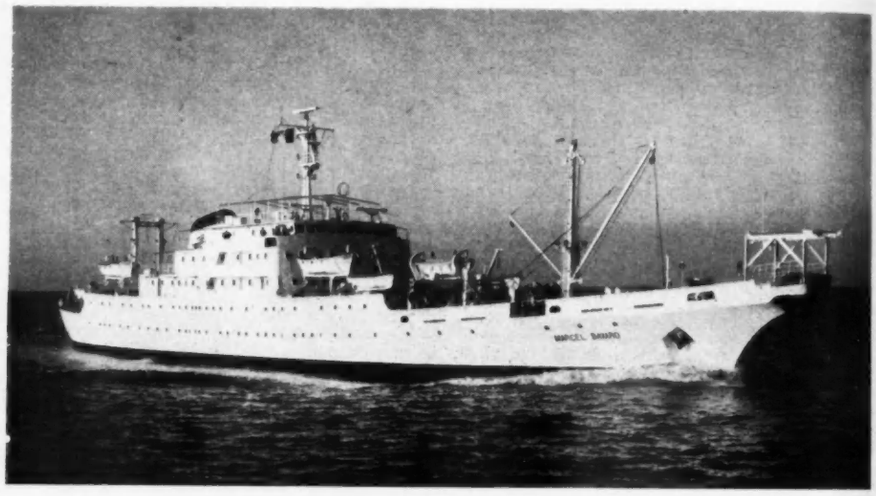
THERE was completed recently the cable ship "Marcel Bayard" which has been built and engined by the Chantiers et Ateliers Angustin Normand, at Le Havre, to the order of the French Ministry of Posts and Telecommunications. The ship, which was launched on June 29, has, as can been seen in our illustration, a distinctive profile and is able to carry 1000 nautical miles of submarine telephone cable with submerged repeaters spliced into the cable. Construction complies with the rules of Bureau Veritas including strengthening for navigation in ice and the principal particulars of the new vessel are :

Length overall	397ft 5in
Length between perpendiculars ...	344ft 6in
Breadth moulded	51ft 2½in
Depth moulded to upper deck	30ft 2½in
Displacement, loaded	7115 tonnes
Deadweight	4418 tonnes
Weight of cables	3300 tonnes
Gross tonnage	4500 tonnes
Speed	14·5 knots

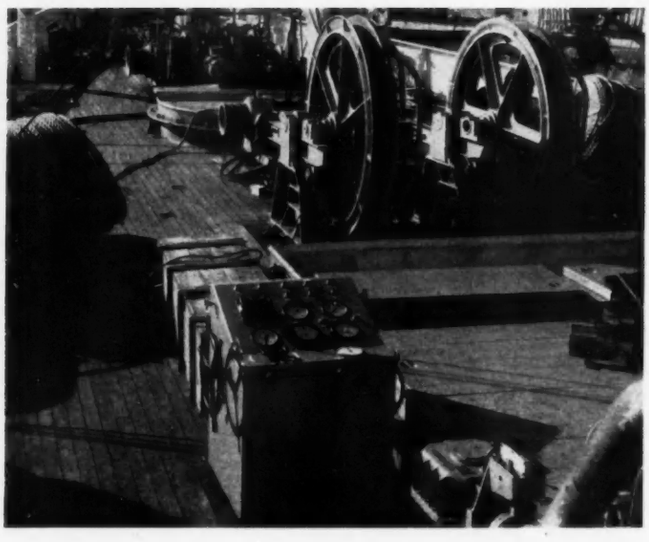
The ship carries a total complement of 106 and it is expected that by the end of the year the "Marcel Bayard" will have completed its first commission, to lay a cable from Perpignan to Oran.

Propulsion is by twin screws powered by diesel-electric machinery and to assist in steering and manoeuvring the ship is equipped with a Plueger "Active" rudder of which the propeller is driven by a 300 h.p. electric motor.

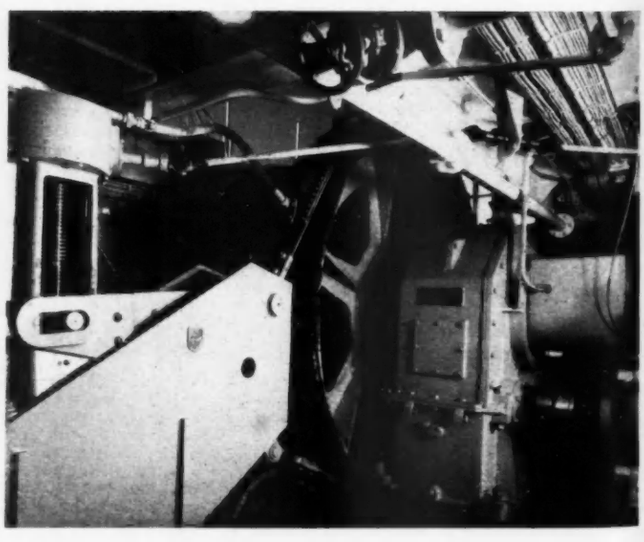
The design provides for the laying and repairing of cables and the cables are carried in three large tanks and one small tank, having a total capacity of 80,507 cubic feet. For handling the cable there are three sets of equipment, two forward and one aft, supplied by the Equipment Division of Submarine Cables Ltd., and owned jointly by Associated Electrical Industries Ltd., and British Insulated Callender's Cables Ltd. Our illustrations show the fore deck arrangements and the aft paying-out cable engine. The forward gear consists of two picking-up and paying-out units having cable drums of 7ft diameter on the tread and 7ft 10in over the flanges, and the port and starboard drums are, respectively, 24in and 34½in wide between flanges and each drum is keyed to the final drive shaft of a totally-enclosed Telcon-Hindmarch reduction gearbox which was described in our issue of April 21, and has Hindmarch "Modern Wheel Drive" oil-operated change gear clutches. Two sets of fully-adjustable fleeting knives are fitted to each drum and the gearboxes, of fabricated steel construction, have ball and roller bearings fitted throughout to reduce friction to a minimum. There are three gears for picking-up and one for paying-out and each box is independently driven by two Vickers-Armstrongs (Engineers) Ltd. V.S.G. size 24 "B" end hydraulic motors which drive through an enclosed 2 : 1 gearbox having twin input shafts and thence to the input shaft of the main reduction gearbox. The hydraulic motors for each gear are driven by a V.S.G. size 50 "A" end pump powered by a 220 h.p. motor. A control console sited adjacent to the capstan on the working deck operates each gear, each of which has the following duties : 30 tons at 0·636 knots ; 20 tons at 0·96 knots ; and 10 tons at 2 knots, the speed being infinitely variable between zero and the maximum for each duty. Both gears pay out cable over the bow at a tension of up to 5 tons and at any speed up to 8 knots. To take the braking load or sustain the cable tension the two V.S.G. size



Cable ship "Marcel Bayard" on trial



Arrangement of foredeck showing port and starboard dynamometers and port control console



After paying-out cable engine, showing mechanical water-cooled braking arrangements

24 "B" end motors coupled together can be used or the combined water-cooled mechanical paying-out and holding brake, which can hold 30 tons at rest or continuously pay-out 8 tons at 8 knots.

One draw-off gear is installed for each engine and each unit is mechanically driven from the main gearbox and fitted with a brake able to exert an effort equal to 1 ton holding-back tension. Each sheave has a root diameter of 7ft and measures 8ft over flanges and can be driven in either direction for picking-up or paying-out; through the medium of bevel gears on the main shaft, operating through a lever-operated dog clutch, a slipping clutch, which is adjustable to prevent damage to special cables and to select optimum draw-off tension, is fitted in the main drive to prevent mechanical failure should there be no slip between cable and sheave. Tachometer and Selsyn units indicate cable speed, while tension is indicated by two sets of combined head "U" sheave dynamometer assemblies, located forward of each cable gear, with 7ft diameter sheaves and capsule-pattern electric-load cells.

The aft cable machinery consists of a single unit with cable drum, identical to the forward starboard unit, driven through an enclosed reduction gearbox having two speeds, one for picking-up and the other for paying-out. There are twin input shafts driven by two V.S.G. size 24 "B" end motors driven by a V.S.G. size 24 "A" end pump powered by a 90 h.p. motor. Cable can be paid out with tensions up to 6 tons at any speed up to 8 knots and the unit includes holding-back gear and dynamometers, as provided for the forward cable machinery, and employs similar braking arrangements. One set of Telcon "Vaut" wire-measuring gear serves two drums, each having a capacity of 140 miles, while tachometer and Selsyn units indicate the speed and length of wire paid out. In the aft drum room is a percentage slack indicator and a slack deviation meter with a percentage slack repeater in the test room, and also cable and wire speed indicators and tensions for the aft cable machine with repeaters in the aft cable engine console, stern and bridge. Similar arrangements apply to the forward cable engines, the cable speed and tensions being repeated at the engines, bows and bridge.

To give close control over speed and for economic working, diesel-electrical propulsion has been adopted and the installation consists of four diesel-driven generators which supply power to four main propulsion motors. Each generator set consists of an Augustin Norman-M.A.N. which develops 1100 b.h.p. at 750 r.p.m., driving a 715kW generator with a 250kW auxiliary generator in tandem. Electric power is supplied to four propulsion motors each of 890 h.p. at 1000 r.p.m. and geared in pairs to twin shafts to give a propeller speed of 170 r.p.m. Other electric equipment includes a 300kW, 220V, d.c. generator and an 87kW, 220V, d.c. generator. All the main electrical gear was built by the Forges et Ateliers de Constructions Electriques de Jeumont, while the electrical deck machinery was supplied by the Etablissements Le Mat, Duche et Fenestre du Havre.

Finnish Feed Water Treatment Plant

WATER supplies in Finland are entirely surface water on account of the impermeability of the granite which lies under the comparatively shallow soil. Since granite is not leachable, and, on the other hand, the water in general remains in prolonged contact with organic matter, Finnish water supplies are low in minerals but show a very high $KMnO_4$ consumption.

In the mid-twenties boiler-feed water was generally given some form of precipitation treatment, normally with caustic soda, with the object of reducing the already low hardness to a minimum, and to neutralise the acidity of the raw water by raising the pH-value to about 8·5. This was followed by mechanical de-aeration, and the addition of sodium sulphite and phosphate to the boiler drums, which were designed for what now would be classed as medium duty.

With the installation since the war of high performance boilers operating at pressures of up to about 135 atmospheres gauge, more modern techniques of water treatment have come to be applied. The water must be completely demineralised, for which ion exchangers would be eminently suitable but for the high organic content of the raw water.

On this problem much work has been carried out in particular by the Central Laboratory at Helsinki, with the aim of removing the organic contamination—often as high as 130 p.p.m.—before it reaches the demineralisation plant. Coagulation by agitating a mixture of water and iron chips in the presence of oxygen—the Niers method—was tried on a laboratory scale in 1952, and gave promising results. Later work showed the value of a fairly heavy addition of ferric chloride, up to about 160 p.p.m., with sufficient lime or caustic soda to maintain optimum pH for coagulation of iron particles and some of the remaining organic matter, which finally was reduced in this way to 7-10 p.p.m.

Although this was a step forward, the ultimate aim had to be to remove all organic material in order to prevent it from accumulating in the strongly basic anion exchange resin bed and eventually fouling it.

The answer appears to have been to some extent the introduction of anion exchange versions of a very porous nature which permit the passage of large organic molecules. These resins, which are in the chloride form and can be regenerated with sodium chloride, are employed as the first stage of the demineralisation plant. Such resins can however be used to remove organic matter only when the water is neutral.

More recently, coagulation and filtration of the raw water is followed by a separate stage for removing organic matter, a so-called "scavenging" stage, before the water reaches the demineralisation plant which comprises a cation exchange, a weakly basic anion exchange, and a strongly basic anion exchange. The last stage removes any organic substances which have leaked through the scavenger.

A feed water treatment plant installed recently at the Heinola fluting board mill of Oy Tampella A.B., Tampere, follows the same principles. The feed is supplied to boilers operating at 100 atmospheres gauge.

The water is taken from the Kymmene river and has the following composition:

	Minimum	Maximum
Conductivity	30	50 micro-mohs per centimetre
Total hardness	10·7	17·8 p.p.m. as calcium carbonate
Carbonate	8·9	16·0 p.p.m. as calcium carbonate
Free CO_2	0	5 mg/l
K Mn O_4 consumption	40	80 mg/l
Soluble silicate, Si O_2	1	5 mg/l

Raw water passes through a coagulation and filtration plant with throughput capacity of 90 cubic metres per hour, where it is subjected to the action of ferric chloride, caustic soda and sodium hypochlorite. This is followed by the demineralisation plant comprising two ion exchange chains, each for a throughput of 23 cubic metres per hour, and having one cation unit containing "Amberlite IR 120" cation exchange resin; one weak base anion unit containing "Amberlite IR 45" anion exchange resin; and one strong base anion unit containing "Amberlite IRA 402" anion exchange resin.

The resins are regenerated with sulphuric acid and caustic soda, and part of the acid used for regeneration is recovered.

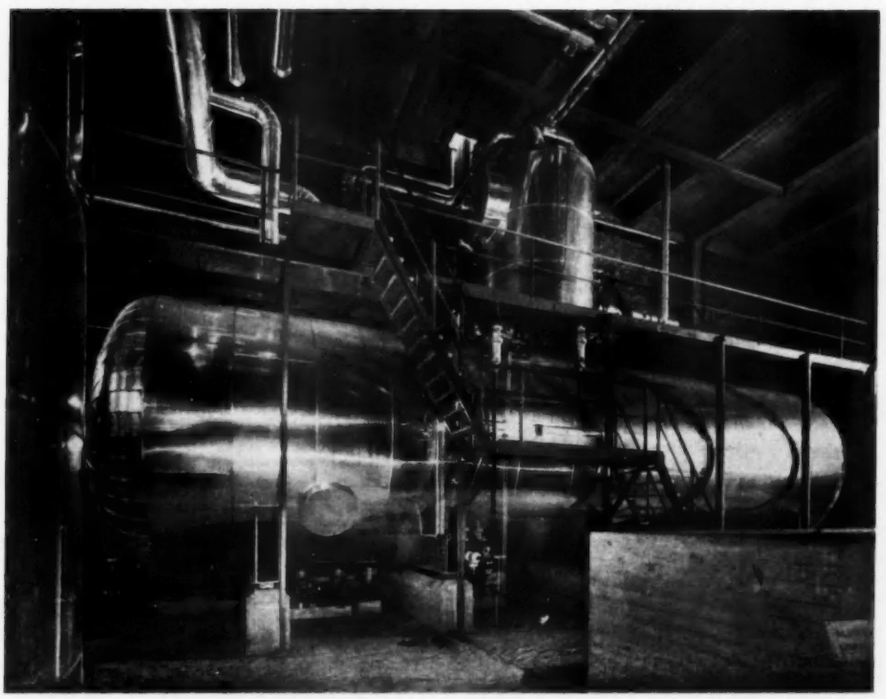
The demineralisation plant is designed for the following water composition:

Cations:	
$Ca^{\cdot\cdot}+Mg^{\cdot\cdot}$	0·36 mills-equivalents per litre
$Na^{\cdot}$	1·11 mills-equivalents per litre
Total	1·47 mills-equivalents per litre
Anions:	
$HCO_3^{\prime}$	0·16 mills-equivalents per litre
$U^{\prime}+SO_4^{\prime\prime}$	1·31 mills-equivalents per litre
Total	1·47 mills-equivalents per litre
K Mn O_4 consumption (maximum)	10 mg/l
Si O_2	5 mg/l
CO_2	16 mg/l

The demineralised output contains a maximum salt contact of 2 mg/l in the form of NaOH, and up to 0·1 mg/l of silica.

The condensate treatment plant includes two ion exchange units containing "Amberlite IR 120" resin which is regenerated with brine.

The de-aerator, which is shown in our illustration, is dimensioned for an hourly output of 170 tons; the de-aerator temperature is 145 deg. Cent. Residual oxygen after de-aeration amounts to a maximum of 0·02 mg/l. The



The de-aerator at Heinola. The horizontal tank holds 80 tonnes of water, a 30-minutes' supply. Above it is the de-aerator dome

CONTINENTAL AFFAIRS *(Continued)*

feed water tank has a volume of 130 cubic metres. Equipment is installed for continuous blowdown of the boiler and heat recovery. The feed is dosed with Na_3, PO_4, N_2H_4, and NH_3.

For drinking purposes, some of the pre-treated (coagulated and filtered) water is passed through a "Magno-Filter" containing magnesium oxide and calcium carbonate, where the pH is raised to about 8 or 9. This plant has a capacity up to 40 cubic metres per hour.

The plant was planned by Tampella in co-operation with William Boby and Co. Ltd., Rickmansworth, and based on the specifications of the Consulting Engineering Association EKONO, of Helsinki.

French Electrical Industry in Moscow

At the French Trade Fair in Moscow (August 15 to September 15) over half the area of the industrial pavilion was taken up by the electrical and electronic industries, in addition to which items of electrical and electronic equipment were shown on the stands of various nationalised enterprises and organisations, such as the S.N.C.F., E.D.F., Radiodiffusion Télévision Française, the Atomic Energy Commissariat, and the Centre National de la Recherche Scientifique.

In the near future there will be put into service in France nine turbo-generator sets of 250MW. Several of these were represented by models, as were the 125MW sets supplied to power stations at Czercza Wodna (Poland) and Ptolemais (Greece). Much attention was caused by a full-scale replica of a bulb turbine of the design developed for the Rance tidal power scheme, also by models of the six 88MVA sets for La Bathie-Roselend. Among distribution equipment exhibited was a 25,000MVA, 525kV circuit breaker of the type supplied for the Soviet super-grid.

A particular attraction was a demonstration of closed-circuit colour television with projection on a screen of 20 square metres. Also shown was an automatic sound film projected for short documentaries, with push-button film selection.

The turnover of the French electrical and electronic industries last year amounted to 11 milliards New Francs. The whole sector employs one-eighth of the total number of engineers in France. Since 1959, the U.S.S.R. has become its foremost export market, the export total rising from 16,000,000 roubles in that year to 22,000,000 roubles (120·5 millions of new francs) last year.

The French Trade Fair in Moscow was visited by approximately 2,000,000 Soviet citizens, including many thousands of engineers, and by technical delegations from all over the Eastern bloc.

Inauguration of Norwegian Reactor

The inauguration of the zero power reactor "Nora" of the Norwegian Atomic Energy Institute (I.F.A.), which will serve in connection with the joint research programme in reactor physics of the International Atomic Energy Agency (I.A.E.A.) and Norway, took place at Kjeller, near Oslo, on November 29. The reactor has been so constructed as to be very flexible and to permit a wide range of experiments to be carried out with it. One of its important aspects is the supporting device for the fuel elements which permits the fuel lattices to be changed readily. It will operate at a power level of only a few watts. Design and construction was carried out by the main contractor, Noratom A/S, in co-operation with I.F.A.

The joint research programme will be carried out under the bilateral Project Agreement concluded between I.A.E.A. and the Government of Norway and the trilateral Supply Agreement concluded between the U.S. Atomic Energy Commission on behalf of the Government of the United States, I.A.E.A. and the Government of Norway, both signed on April 10, 1961.

The programme aims at obtaining precise and widely applicable reactor physics data on cores with mixed and variable lattices moderated by light water, heavy water and mixed heavy and light water. In addition to the critical assembly "Nora" itself, Norway is making available two reactor cores, one consisting of natural uranium and the other of slightly enriched uranium. A third core, provided under the supply agreement between I.A.E.A. and the U.S.A., consists of fuel enriched to 3 per cent in the radioisotope U.235. This core was originally used in development work for the nuclear merchant ship "Savannah" and contains approximately 42 kg of U-235. This is the first lease of special nuclear material through the Agency to one of its Member States.

Fabric Separating Machine

In the manufacture of fabrics, especially cottons, the machines (looms, dryers, &c.) frequently process a double width of material which is subsequently cut down the middle. For this purpose, selvedges are formed in the centre by leaving out a few warp threads. The gap in the warp helps to guide a separating knife in the final stage of production.

When carried out by hand, separation is a tiring and inaccurate procedure. A machine designed by V.E.B. Carl Zeiss, Jena, separates the fabric automatically at a rate of 10m to 25m per minute, the accuracy along the 4mm wide centre selvedge being $\pm$1mm. At cross seams the centre selvedge may be displaced by as much as $\pm$20mm, so that at such places the knife must be shifted quickly in order to prevent great lengths of bad cutting.

The rotary knife is positioned by a servo operated by the error signal from two opposing photocells. This is done in the following manner. The selvedge gap is illuminated over an area 40mm by 40mm by a parallel beam, the transmitted light falling on the edge of a prism. This splits the beam into two parts which are made to fall on two cadmium sulphide photocells which form two of the arms of a Wheatstone bridge. As long as the selvedges are centrally placed in relation to the edge of the prism, the light beam is divided symmetrically and the two photocells are in balance, so that the error signal from the magnetic amplifier is zero. On the other hand, any displacement of the selvedges gap gives rise to a positive or negative error signal which initiates a corrective movement of the prism system to which the circular fabric knife is attached. A safety circuit immediately stops the machine if a fault develops (e.g. a failure of the lamp which illuminates the selvedge) and a lamp lights up showing the location of the fault. Response of the control circuit is made more sensitive by feeding back to an auxiliary winding of the magnetic amplifier a rate-dependent signal. This is obtained, not from a tachogenerator driven by the servo-motor (since this would excessively increase its inertia), but from a condenser charging and discharging through a potentiometer coupled to the servo.

Nano-Second Switching with Thin Magnetic Foil

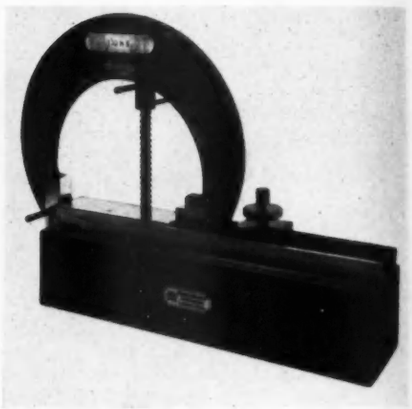
Magnetic foils consisting of 80 per cent nickel, 10 per cent iron, and permalloy, and having a thickness of only about 0·0001mm were recently demonstrated by Siemens & Halske Aktiengesellschaft, Berlin–Munich. Layers of such thickness already appear transparent. Because of the small degree of anisotropism and low magnetostriction, a single elementary magnetic reversal takes no more than about one nano-second (10^{-9} second). This is very considerably shorter than the reversal time of a small annular magnetic core of, say, 1·2mm diameter which is of the order of a few microseconds. For this reason such layers are of considerable interest in the manufacture of information stores for computers. In addition, instead of having to thread the miniature cores laboriously with wires, the new magnetic layers make it possible to apply the necessary circuits by sputter techniques on top of an intermediate insulating layer.

Calibration of Caliper Gauges

An instrument for checking caliper gauges has been put on the market by Richard Knaute, Arno-Förster-Strasse 4, Limbach-Oberfrohna 1, German Democratic Republic (Agent : Nonius Ltd., 38, Beethoven Street, London, N.W.10). As shown in the accompanying illustration, it comprises a cast iron base with angle iron guides between which there is a movable slider. The slider may be clamped, but this still permits fine adjustments.

At the left-hand end of the slider there is an end plate with retaining spring for a mandrel of known size to be inserted.

The step at the rear of the base has tappings for a threaded column. Equipped with pins



Instrument for checking caliper gauges using a measuring mandrel in combination with end measures

covered with artificial cloth, the column provides a stop for the gauge. The end measure combination is built up, using an accurately sized mandrel at the end, the diameter of which is selected so as to allow the gauge under test just to slip over the combination. Nominally 5mm in diameter, the mandrels are supplied in sets of seventy-five to D.I.N. and I.S.A. standards, in sizes between 1 and 100 microns above and below nominal. They are stated to be cylindrical to within $\pm$0·3 micron.

[Reply Card No. 1396]

Lybian Oil Port

The official opening took place on October 25 of the oil port of Port Brega (Marsa el Brega), Lybia, and a 170km long 30in pipeline from the Zelten oilfield. Since 1959 when the field was discovered by Esso Standard Lybia Inc., thirty-eight wells have been sunk of which thirty-four became productive. After completion of the installations next year, an annual output of 6,000,000 tons of crude oil is expected. For the country's domestic consumption a refinery is being constructed which is to go on stream in 1963.

THE AMERICAN SCENE

By Our American Editor

Slip-Form Paving of California Highways

SLIP-FORM paving has been in use in California state highway construction for over a year. It immediately caused much interest among highway engineers who see in the method not only a major advance in concrete paving practice but the potential of reduced paving costs. Recently, the highway construction industry, represented by the Griffith Company of Los Angeles, proposed a demonstration of the capability of a slip-form paver manufactured by a California firm. The plan was to pave a trial section in the Los Angeles River channel invert contract the company then held with the U.S. Army Corps of Engineers under simulated highway conditions for evaluation by the California Division of Highways. This proposal was accepted and as a result of critical review and testing of the 24ft wide concrete slab constructed in that trial section, the State Highway Engineer authorised the use of the slip-form paving method in state highway construction on an experimental basis. Two paving contractors, Gordon H. Ball, Incorporated, of Danville, and the Griffith Company of Los Angeles, immediately requested permission to employ this new method on several of their going highway contracts.

The contracts selected for the initial slip-form pavement construction in California were: (*a*) the construction of approximately 14 miles of two-lane 24ft wide pavement, requiring 47,890 cubic yards of "Class B" concrete; (*b*) a project joining the south end of the above contract and extending the 24ft wide two-lane pavement approximately six miles farther to the south, requiring 17,070 cubic yards of "Class B" concrete; and (*c*) the construction of approximately 15½ miles of 24ft wide pavement and 7·7 miles of four-lane divided highway, requiring 47,400 cubic yards of "Class B" concrete. The first two contracts, which adjoin as indicated above, were adapted to a continuous paving operation from one end to the other and were in many aspects equivalent to a highway paving project approximately 20 miles in length amounting to a total of 64,960 cubic yards of concrete.

The slip-form paver used consists essentially of two self-propelled crawler track assemblies with treads 20in wide and 18ft long which support the main body through four heavy-duty hydraulic rams, two at each track assembly. The main body consists of the structural support members, a travelling receiving hopper, a fixed full-width feed hopper, full-width transverse vibrating tubes mounted in the throat of the feed hopper, a primary screed or extrusion meter which is full-width and 80in fore and aft, a secondary screed or transverse float which is full-width and approximately 24in fore and aft, a transverse weakened plane joint cutting bar mounted between the primary and secondary screeds, slab depth side forms 15ft long beneath the main body, a "V"-shaped finish float at the rear, a longitudinal weakened plane joint cutter mounted near the apex or leading end of the "V" float, a timing device at the rear of one track assembly for the automatic interval control of transverse weakened plane joints, a 100kVA diesel-electric generator power supply, a control panel for the operator, and an electrical guidance system. Multiple lengths of trailing forms 15ft each are attached as necessary to the rear end of the side forms beneath the main body.

Fig. 1—Close-up view of the right rear elevation control probe on the slip-form paver

To provide for the installation of 30in lengths of reinforcing steel as tie bars across the longitudinal centre joint an apparatus was developed which attaches to the front plates of the feed hopper and consists of two reels of baling wire and a drum guide arrangement. The device is designed to feed two strands of baling wire over the guide drum and into the centre of the slab at mid-depth. Adequate room is provided between the reels of baling wire and the drum guide for an operator to affix tie bars at 30in intervals by twisting a strand of baling wire around each end of the bar. Steady but light tension is maintained in the baling wire by the forward advance of the paver operating against the resistance of previously installed bars.

Perhaps the most important distinguishing characteristic of this slip-form paver is the guidance system which maintains the machine on pre-determined alignment and grade for the completed pavement. Guidance is accomplished through the use of a meticulously accurate installation of two lines of tensioned 16- or 18-gauge piano wire at pre-established and constant lateral and vertical offset from each edge of pavement. These wire lines serve as guides for the paver.

Sensing elements which operate along these wire guides are attached to the main body of the paver and consist of a slotted feeler, which straddles the wire, together with sensitive limit switches which are actuated by the feelers. Five feelers are used. Four are mounted with the feeler in a horizontal configuration for elevation control while one element is mounted with the feeler in a vertical configuration for steering control.

The probes for elevation control are mounted at each corner on the main body by extension arms which position the elements around and clear of the track assemblies so that the feelers are over the wire guides. Each elevation control probe triggers the operation of one of the hydraulic rams. When a signal is transmitted from any one of the probes the hydraulic ram corresponding to the position of that probe is either raised or lowered. In being raised or lowered, the ram moves the corresponding corner of the main body of the machine up or down which, since the probe is attached thereto, repositions the probe in relation to the wire guide and ends the signal for correction. As the main body of the machine moves up or down, the screeds are raised or lowered also, because they are attached integrally thereon.

Alignment or steering control is provided through the operation of one probe which can be mounted at either forward corner of the paver. This probe gives control automatically using the differential speed of the two independently propelled track assemblies.

At the start of the initial operation, subgrade construction consisted of cement treating four inches of 1½in maximum untreated base aggregate, 26ft wide. The elimination of the side forms by the slip-form operation facilitated the construction of the cement-treated subgrade 12in beyond the edges of the concrete pavement on either side to obtain better control of edge pumping by the completed slab.

The material to be treated was already in place on the roadway. Thus construction procedures consisted of: (1) bringing the top of compacted untreated material to proper grade and cross-section; (2) loosening and forming the top 4in into two equally sized windrows side by side on the roadbed; (3) distributing the proper quantity of cement into notches formed in the top of each windrow; (4) mixing; (5) spreading and compacting; and (6) finish grading to final grade and cross-section. The normal procedure for conventional paving involves similar general procedures for subgrade construction; however, conventional subgrading equipment operates on the side forms. In slip-form paving such side forms are not used, and different methods become necessary. Furthermore, very accurate subgrade both under the track assemblies as well as under the pavement is needed for an optimum performance of the paver and a minimum overrun of concrete quantities.

The contractor's method was to do initial grading and windrowing with a motor-grader operated to blue tops set by his forces from the engineer's control stakes. The control stakes were set at the lateral offset of 3·71ft, which

Fig. 2—Rear view of self-propelled mixer discharging cement-treated subgrade material

THE AMERICAN SCENE *(Continued)*

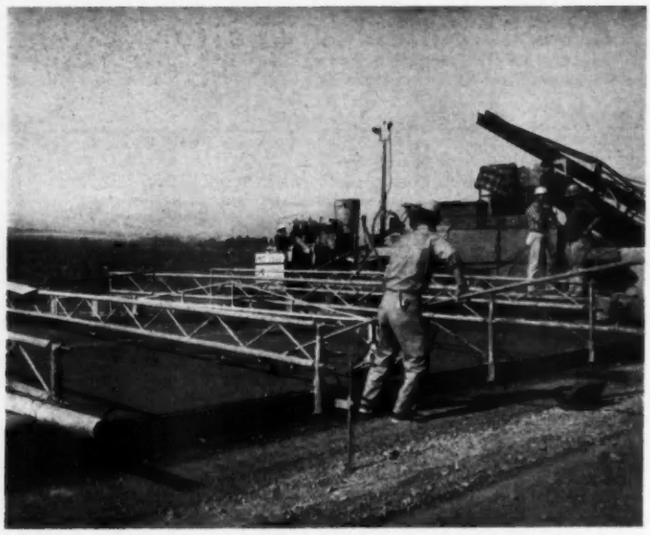


Fig. 3—Hand-finishing and edging of pavement between the trailing forms

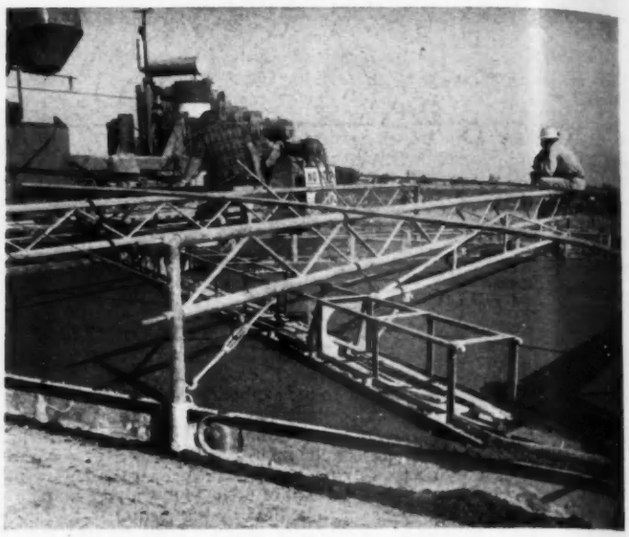


Fig. 4—V-shaped float between the trailing forms, for finishing the pavement surface

would conform to the offset of the control wire to be installed for the subsequent paving operation, at the elevation for the bottom of pavement, and at 50ft intervals along line. Where vertical curves were encountered the longitudinal interval between the control stakes was reduced to 25ft.

Cement was distributed on the windrows with a distributor, and mixing was accomplished with a large self-propelled road mixer. The initial spread of the mixed subgrade materials was done with a spreading device on the mixer. Following initial compaction a tractor-towed spreader with automatic hydraulic controls for the control of cross-slope and longitudinal grade was used for finish grading. During the operation of this tractor-towed automatic spreader, the staking crew kept a constant check of both the finished grade and the cross slope by the use of templates. After laying an asphaltic curing seal, the subgrade was ready for pavement construction.

The construction of the cement-treated subgrade on the (*c*) contract varied from that on the (*a*) and (*b*) contracts. In this instance the materials to be treated were not already in place when the operation was started but were imported and spread in a single windrow through an enlarged spreader box as part of this phase of the work. The cement was distributed to this single windrow with a distributor similar to that described above ; however, the most significant change was in the equipment used for mixing.

In order to mix the outsized windrow comprising all materials for a 4in deep treatment 26ft wide, the contractor employed a self-propelled pugmill mixer (Fig. 2) assembled by his own forces. This unique machine, known as " the Monster," elevates all materials in the windrow by bucket conveyor onto an overhead enclosed belt which feeds the forward end of a double-shafted pugmill mixer. The mixed materials are discharged onto the subgrade in twin windrows. Spreading and compaction is performed conventionally with blade and rollers and final grading is performed to blue tops by a blade with automatic control.

For his work on contracts (*a*) and (*b*), the contractor used a triple batch plant. Initially, this plant was charged by a single clamshell shovel. In later stages of the work a belt conveyor was added for charging the sand. For transporting the dry batches to the paving mixers on the grade, the contractor used his fleet of fast and large batch trucks with specially designed six-batch bodies. Mixing was done by a pair of dual drum pavers, and each mixer was modified to discharge the mixed concrete by belt conveyors instead of the usual bucket. These 30ft self-driven belt conveyors were specially constructed and were mounted on reinforced booms controlled by the mixer-operator.

The two mixers are operated on the pavement subgrade side by side immediately in advance of the slip-form paver. Openings at approximately 500ft intervals are made in the wire guides to permit ingress and egress of the batch trucks which line up on the subgrade in front of the mixers. As paving progresses this entire equipment " train " progresses down the grade at approximately 8ft per minute. When one opening in the wire guide is passed by the batch trucks and another is opened up, workmen quickly splice in the missing portion of wire, and the operation continues without interruption.

The slip-form paver sets the pace for the entire operation. Each mixer moves forward 6ft or 7ft between each batch while the skip is in the up position. This puts them in position to discharge the succeeding batch into the receiving hopper of the slip-form paver while the mixer is stationary and the paver steadily advancing. To compensate for variations in the rate of delivery of mixed concrete, the paver is provided with controls at the operator's position for varying the speed from zero to maximum paving speed of approximately 15ft per minute. This is a rheostat control of the electric propulsion motors with stepless change of speed within the range. The maximum forward travel speed is 32ft per minute.

Upon discharge of the concrete into the receiving hopper the operator distributes ti laterally into the feed hopper below by propelling the receiving hopper from side to side and opening the gate thereon. Concrete is vibrated from the feed hopper under the primary screed and consolidated as the paver moves forward. A vibrating " T "-section transverse joint cutter is hydraulically rammed into the fresh concrete at given intervals producing a $\frac{3}{4}$in wide groove 3in deep. The second screed irons out any irregularity in the surface caused by cutting the groove. Immediately behind and centered on the secondary screed a vibrating tool is installed to cut a longitudinal centre-line joint, $\frac{1}{4}$in wide and 2in deep. Attached to the side forms beneath the main body of the paver are 30ft to 45ft of trailing forms on each side. Under the conditions encountered on the (*a*) and (*b*) contracts it was found that 30ft of trailing forms was adequate.

Floating freely on the surface of the fresh pavement between the trailing forms a V-shaped float (Fig. 4) is towed by an attachment at the apex, to remove many minor surface deviations. Just aft of the apex of the chevron float a simple jointing tool finishes the longitudinal joint which was left an open groove. Edging and any hand-floating (Fig. 3) is done between the trailing forms and behind the float. One burlap drag attached to the rear trailing form cross brace followed by a second burlap drag pulled by hand ten or fifteen minutes later completes the finishing.

A pigmented compound is applied by hand operated spray bar (Fig. 5) at 1 gallon per 150 square feet as a curing seal.

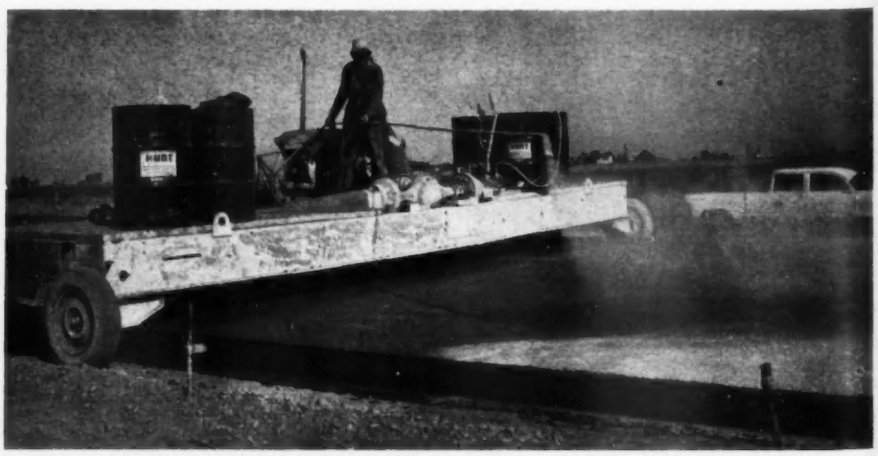


Fig. 5—Application of a pigmented curing compound from a self-propelled bridge following the paver

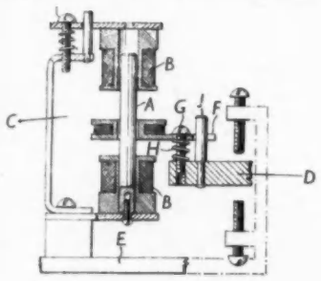
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

ELECTRICAL ENGINEERING

880,437. December 24, 1958.—ELECTRICAL TRANSDUCERS, James Fairhurst, Laneside New Farm, Blossoms Lane, Bramhall, Chester.

This invention relates to electric transducers of the kind operating on the transformer principle for the conversion of mechanical movement into related variations in the nature of an electric current. It proposes to overcome the drawback of certain transducers that the range of coil movement over which the induced electrical characteristics are substantially linear is limited to approximately half the physical length of the axially-shortest of the opposed coils. In the embodiment illustrated, a substantially straight rod-like vertical ferrite or other magnetic core *A* provides a fixed magnetic coupling between two opposed primary coils *B*. Between the coils and coaxial with them is a preferably narrow secondary coil *C* which is free to move in an axial direction under the influence of the element *D* which moves relative to the primary coils in a direction substantially parallel to the axis of the magnetic core. The primary coils, their associated core, and the components which maintain them in their relationship to one another form a unit which is carried by a relatively stationary element *E*. The support member *F* for the secondary coil may be rigidly fixed to the moving element or may be adjustably fixed thereto by means such as the screw *G*, spring *H*, and guide-pin *J*, to provide for the axial adjustment of the coil relative to the moving element and the magnetic centre of



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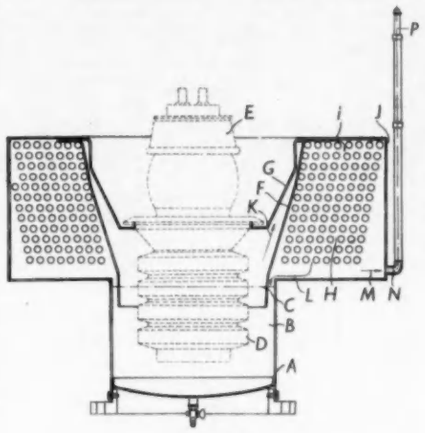
the primary coil and core system. Similarly the primary coil and core unit may be rigidly fixed to the relatively stationary element *E* or may be adjustably fixed by centralising adjustment means. It is unnecessary to provide centralising adjustment means for both the secondary coil and the primary coil and core unit of the same transducer. The specification also illustrates these arrangements. The transducer can be adjusted to give zero secondary output at the energising frequency, by the simple mechanical operation of turning the primary system adjusting screw to balance the opposed magnetic fields of the primary coils, the relative positioning of the secondary coil at the balance point between the primaries being accomplished similarly by turning the associated adjusting screw.—*October* 25, 1961.

ELECTRONICS

880,493. April 23, 1958.—COOLING SYSTEMS OF HIGH-POWER ELECTRONIC TUBES, Siemens and Halske Aktiengesellschaft, Berlin and Munich, Germany.

One of the objects of this invention is to increase the volume of the vapour condensed in the condenser of a cooling system for high-power electronic tubes, and thus to improve the efficiency of a cooling system. Referring to the drawing, a cooling chamber *A* is filled with a cooling liquid *B*. The reference *C* denotes a predetermined level of the cooling liquid in which the anode part *D* of a high-power electronic tube *E* is immersed. As soon as the tube is heated, the cooling liquid starts to absorb heat as a result of which some of the liquid is vaporised. An internal dividing wall *F* is arranged between an inner side wall *G* of a condenser and a condenser tube system *H* housed in the condenser. The base of the condenser is joined to the side wall of the chamber *A* above the predetermined level of the liquid. The condenser is an annular body through the centre aperture of which the electronic tube extends. Between the inner side wall and an outer side wall *J* there is disposed a top wall. The vapour emerging from the liquid rises, as indicated by the arrow *K*, in a vapour-conducting funnel formed by the inner side wall *G* of the condenser and the internal wall *F* and reaches the condenser-tube system at a location remote from the cooling liquid. The vapour moves from this location and passes, as indicated by the arrow *I*, between the condenser-tube system by which it is condensed. The resulting condensed liquid drops down and returns to the cooling liquid, as indicated by the arrow *L*. The internal wall *F* extends from below the level of the



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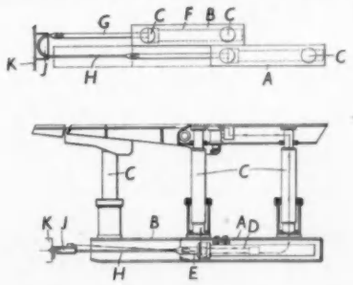
cooling liquid to the said location remote therefrom. It is thus made certain that the vapour rises through the vapour-conducting funnel instead of reaching the condenser-tube system in an uncontrolled fashion close to the cooling chamber. Any vapour not condensed by the condensation system, moves in the direction of the arrow *M* when the pressure of the vapour exceeds that of the atmosphere and reaches a vapour exhaust *N* arranged in the outer side wall of the condenser. The vapour exhaust is connected to an indicating device *P*, for instance a contact thermometer, which is operated if the vapour is not being condensed at a predetermined rate.—*October* 25, 1961.

MINING EQUIPMENT

881,364. January 16, 1959.—HYDRAULIC RAM DEVICES APPLICABLE TO MINE ROOF SUPPORTS, Gullick Ltd., Kirkless Street, Wigan. (*Inventor: Jeffrey William Seddon*).

One particular application of this invention is to a self-advancing or "walking" roof support for mines. An object is to provide a self-advancing roof support which is capable of making much greater "steps" for a given stroke and size of ram than has been the case with similar devices. The support shown on the drawings comprises two side by side base members or



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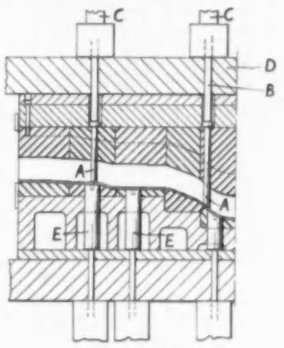
feet *A* and *B* slidably connected together. Each base carries two hydraulic props *C* adapted to support a roofing bar. The foot *A* incorporates a hydraulic ram comprising a cylinder *D* and ram proper *E*. The foot *B* incorporates a hydraulic ram with a cylinder *F* and ram proper *G*. The outer ends of the rams are linked together by a flexible member such as a wire rope, chain or belt *H* which runs over an anchorage shoe *J* attached, in this particular case, to a coal conveyor at *K*. In the position shown in the upper view a cut or strip has been made, the conveyor has been pushed over and it is required to advance the support *A* up to it. Due to the anchorage of the rams to the conveyor pushing over of the conveyor will have extended both rams as shown. The props of the support are then lowered from the roof and hydraulic pressure is supplied to the cylinder *D*. As the ram *E* is held stationary, the foot is advanced into the position shown in dotted lines. Hydraulic pressure is supplied simultaneously to the cylinder *F* so that the ram *G* is retracted and as a result the foot *A* is advanced still further, i.e. from the position shown in dotted lines to the position shown in chain lines. The support is then re-set to support the roof. Following the next cut or strip of the coal face a similar procedure takes place except that this time the foot *B* is advanced. Thus, the supports alternately make two steps forward following each cut. This increased advance is achieved without any increase in the length of stroke of the rams and without the ram extending backwards beyond the rear of the support.—*November* 1, 1961.

PRESSES

881,010. April 28, 1960.—POWER PRESSES, Rubery, Owen and Co. Ltd., Darlaston, Wednesbury, Staffs. (*Inventors: Ronald Betteridge and Sidney Blower.*)

In the arrangement illustrated, vehicle axle pressings of substantial dimensions are formed from thick blanks which are fed mechanically into and removed mechanically from the press. Control of the blank and pressing is effected by pins *A* which are movable vertically through the top tool and are loaded by compressed air cylinders. The extent of the downward movement of each pin is limited by a head on the upper end. The head of each pin is engaged by an aligned movable pin *B* projecting down from a transverse bar *C* which slides in the ram *D* and is loaded at its ends by compressed air cylinders. The pressure in the air cylinders is maintained substantially constant. The length of the pins *A* is such that in the open position of the press they project for a substantial distance below the top tool. When the top tool is brought down by the ram, the



No. 881,010

pins *A* engage the blank after the tool has moved down through a predetermined distance and locate the blank positively and accurately in the bottom tool during the remainder of the downward movement. As the pins are loaded by the compressed air cylinders, the pressure exerted by them on the blank remains substantially constant throughout the downward movement. On completion of the pressing operation, the top tool moves up but the control pins remain in engagement with and exert a constant downward pressure on the pressing. This ensures that the pressing is stripped from the top tool, and is held in the bottom tool until it is ejected by upward movement of the pins *E* after the top tool has moved up through a predetermined distance. During ejection the control pins continue in engagement with the pressing so that the ejection is effected under control and the pressing is released smoothly without risk of distortion. After the pressing has been completely ejected, the control pins are carried up clear of the pressing, which is then supported by the ejector pins and can be engaged by any convenient mechanical handling means for removing it from the press. The location and spacing of the control pins along the length of the pressing can be selected to suit its form and the pressure applied to each pin by the air cylinders can also be selected according to conditions. For example, if the release from the tools of one part of a pressing is more difficult than the release of another part, the pressure applied through a pin engaging that part can be increased to ensure even release at a predetermined height.—*November* 1, 1961.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Dec. 11.—BOURNEMOUTH AND DISTRICT BRANCH : South Western Hotel, Holdenhurst Road, Bournemouth, "Commercial Refrigeration," 8 p.m. ★ CENTRAL LONDON BRANCH : Demonstration Theatre, Strand Electric and Engineering Company Ltd., 29, King Street, London, W.C.2, "Stage Lighting 1961," 7.15 p.m. ★ NORTH WEST LONDON BRANCH : Century Hotel, Wembley, Films, 8.15 p.m. ★ MID-ESSEX BRANCH : White Hart Hotel, Tindal Street, Chelmsford, Films, 7.45 p.m.

Tues., Dec. 12.—BRISTOL AND WEST OF ENGLAND BRANCH—GRADUATE SECTION : Grand Hotel, Bristol, "Telephone Repeaters," K. F. Broome and A. J. White, and "Railway Electrification," D. T. Davidson, 8 p.m. ★ CHESTER BRANCH : Blossoms Hotel, Chester, "Static Switching Control Systems," B. A. W. Midgley, 7.45 p.m. ★ GLASGOW BRANCH : Kenilworth Hotel, 5, Queen Street, Glasgow, "Colour Television," 8 p.m. ★ GLOUCESTER AND DISTRICT CENTRE : Royal Hotel, Station Road, Gloucester, "Control Centres for Modern Industry," 8 p.m. ★ NATIONAL EVENT : Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Towards Better Office Lighting," A. Wilcock, 6.15 p.m. ★ OXFORD AND DISTRICTS BRANCH: Board Room, Employment Exchange, St. Aldates, Oxford, "Public Electric Supply Distribution," J. L. Taylor, 7.30 p.m. ★ YORK BRANCH : Royal Station Hotel, York, "Oil as Fuel," 7.30 p.m.

Wed., Dec. 13.—BRISTOL AND WEST OF ENGLAND BRANCH : Turk's Head Hotel, Exeter, "Industrial Cabling," 8 p.m: ★ EAST ANGLIA (THETFORD) CENTRE : Red Lion Hotel, Thetford, Norfolk, "Electric Floor-warming and Ancillary Equipment," E. A. Moneypenny, 7.30 p.m. ★ LUTON BRANCH: College of Technology, Park Square, Luton, Films, "The National Grid" and "Planned Electrification," 8.15 p.m. ★ WOLVERHAMPTON AND DISTRICT BRANCH : Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, "Electrically-operated Fire Detecting and Alarm Systems," A. Whitehouse, 7.45 p.m.

Thurs., Dec. 14.—BRADFORD AND DISTRICT BRANCH : Midland Hotel, Bradford, "Horology," W. Barton, 7.30 p.m. ★ SOUTHAMPTON BRANCH : Polygon Hotel, Southampton, "New Techniques in Stereosound," F. H. Brittain, 8 p.m.

Fri., Dec. 15.—COVENTRY AND DISTRICT BRANCH : Conservative Rooms, 16, Queens Road, Coventry, "A Simple Approach to Computers," M. M. Robins, 8 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Dec. 13.—SCOTTISH SECTION : Department of Natural Philosophy, The University, Drummond Street, Edinburgh, "Jodrell Bank," J. B. Wilson, 7 p.m. ★ MERSEYSIDE SECTION : Walker Art Gallery, Liverpool, "Nuclear Power Station Instrumentation," M. W. Jervis, 7.30 p.m. ★ NORTH EASTERN SECTION : Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, "Masers and Parametric Amplifiers," T. H. Wilmhurst, 6 p.m.

Thurs., Dec. 14.—TELEVISION GROUP : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Symposium on "Constant Luminance Colour Television," 6 p.m. ★ WEST MIDLANDS SECTION : Electrical Engineering Department, The University, Birmingham, "The R.R.E. Radio Telescope Interferometer," H. Gent, 6.15 p.m. ★ SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Jodrell Bank," J. B. Wilson, 7 p.m.

COMBUSTION ENGINEERING SOCIETY

Wed., Dec. 13.—SCOTTISH REGION : Royal Hotel, Union Street, Dundee, Discussion on "Operational Boiler Defects and Methods of Repair," opened by F. Mosley, 10.30 a.m., and a Discussion on "The Problem of Grit and Dust Emission," opened by H. Westwood, 2 p.m.

DIESEL ENGINEERS AND USERS ASSOCIATION

Thurs., Dec. 14.—Institute of Marine Engineers, 76, Mark Lane, London, E.C.3, Presentation of Annual Report on "Oil and Gas Engine Working Costs and Performance," 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Dec. 11.—LEEDS CENTRE : City Art Gallery, The Headrow, Leeds, "The Problems of Lighting Urban Motorways," G. K. Lambert, 2 p.m. ★ LEICESTER CENTRE : Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, "Lighting for Inspection," H. E. Bellchambers and S. M. Phillipson, 6.15 p.m.

Tues., Dec. 12.—LONDON CENTRE : Federation of British Industries, Tothill Street, London, S.W.1, Discussion on "Applying the Code," opened by H. H. Ballin, 6 p.m.

Wed., Dec. 13.—SWANSEA GROUP : Demonstration Theatre, South Wales Electricity Board, The Kingsway, Swansea, "Luminous Ceilings and Modular Fittings," R. L. C. Tate, 6 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Thurs., Dec. 14.—LONDON BRANCH : National Liberal Club, Whitehall Place, London, S.W.1, Joint Meeting with the Institute of Metals, "Feeding Non-Ferrous Castings," E. C. Mantle, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Dec. 11.—WEST OF ENGLAND SECTION : Small Engineering Lecture Theatre, The University, University Walk, Bristol, 8, "Trials and Operation of the Gas Turbine Ship 'Auris'," R. M. Duggan and A. T. O. Howell, 7.30 p.m.

Tues., Dec. 12.—Memorial Building, 76, Mark Lane, London, E.C.3, "Land Practice in Modern Steam Plant," F. Dransfield and J. L. Gray, 5.30 p.m.

Thurs., Dec. 14.—NORTH EAST COAST SECTION : Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne, "Trials and Operation of the Gas Turbine Ship 'Auris'," R. M. Duggan and A. T. O. Howell, 6.15 p.m. ★ KINGSTON UPON HULL AND HUMBER AREA SECTION : Royal Station Hotel, Kingston upon Hull, "Looking Back on Nuclear Propulsion," R. P. Williams, 7.30 p.m.

INSTITUTE OF METALS

Mon., Dec. 11.—SCOTTISH LOCAL SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Progress in the Electron Theory of Metals," J. A. Catterall, 6.30 p.m.

Tues., Dec. 12.—OXFORD LOCAL SECTION : Cadena Café, Cornmarket Street, Oxford, "Lattice Spacing Determination as a Tool in Metallurgical Research," G. V. Raynor, 7.15 p.m. ★ SOUTH WALES LOCAL SECTION : Metallurgy Department, University College, Swansea, "Some Theoretical Aspects of the Sintering of Metal Powders," G. A. Geach, 6.30 p.m.

Thurs., Dec. 14.—SOUTHAMPTON METALLURGICAL SOCIETY : The University, Southampton, "Fatigue," T. R. G. Williams, 7.15 p.m.

INSTITUTE OF NAVIGATION

Fri., Dec. 15.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, Films, 5.30 p.m.

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

To-day, Dec. 8.—APPLIED SPECTROSCOPY GROUP : 4, Hamilton Place, London, W.1, "Recent Development on X-ray Fluorescence Spectroscopy," J. L. de Vries, 2.30 p.m. ★ ELECTRON MICROSCOPY GROUP : 47, Belgrave Square, London, S.W.1, "Electron Microscopy in Japan," T. Mulvey, 2.30 p.m. ★ SOUTH WALES BRANCH : University College, Cardiff, Annual General Meeting, and "Structural Studies on Fibrous Proteins," R. E. Burge, 6 p.m.

Mon., Dec. 11.—LONDON AND HOME COUNTIES BRANCH : 47, Belgrave Square, London, S.W.1, "Static Electricity," P. S. H. Henry, 2.30 p.m.

Tues., Dec. 12.—MIDLAND BRANCH : Midland Institute, Birmingham, "The Observation of Radio Stars," P. F. Scott, 6.30 p.m. ★ STRESS ANALYSIS GROUP : 47, Belgrave Square, London, S.W.1, "Strain Gauges," 2.30 p.m. ★ ELECTRONICS GROUP : 47, Belgrave Square, London, S.W.1, "Integrated Electronics," J. W. Granville, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Dec. 12.—Great George Street, Westminster, London, S.W.1, "Maintenance of Hydro-electric Schemes and the Development of Sidestream Intakes," H. D. Morgan and D. D. Reid-Thomas, 5.30 p.m.

Thurs., Dec. 14.—TRAFFIC ENGINEERING GROUP : Great George Street, Westminster, London, S.W.1, Discussion on "Traffic Design of Parking Garages," introduced by L. T. C. Beasley, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Dec. 8.—MEDICAL ELECTRONICS DISCUSSION GROUP : Savoy Place, London, W.C.2, Discussion on "The Peltier, Hall and Seebeck Effects," 6 p.m. ★ NORTH MIDLAND CENTRE : Lecture Theatre, Y.E.B. Offices, Ferensway, Hull, "Electricity in the Chemical Industry," P. McDermot, 6.30 p.m. ★ WESTERN CENTRE : Technical College, Gloucester, "Some Unusual Types of Electrical Machinery," G. H. Rawcliffe, 7.30 p.m.

Mon., Dec. 11.—LONDON GRADUATE AND STUDENT SECTION : Savoy Place, London, W.C.2, Presidents' Address, "The Professional Engineer and an Expanding Industry," G. S. C. Lucas, 6.45 p.m. ★ ARBORFIELD DISTRICT MEETING : Unit Cinema, 3 (Tels.) Training Bn., R.E.M.E., Arborfield, Berks., "Design of Service Equipment," B. W. Norman, 7 p.m. ★ EAST ANGLIAN SUB-CENTRE : College of Arts and Technology, Cambridge, "Co-operative Education in Engineering in the U.S.A.," R. L. Cannel, 6.30 p.m. ★ NORTH-EASTERN CENTRE : Neville Hall, Westgate Road, Newcastle upon Tyne, "Progress in Oil-Filled Cables and their Accessories," A. N. Arman, F. J. Miranda and G. B. Bishop, and "The Influence of Ageing on the Characteristics of Oil-Filled Cable Dielectric," P. Gazzana-Priaroggia, G. L. Palandri and U. Pelagatti, 6.15 p.m. ★ WESTERN CENTRE : South Wales Institute of Engineers, Cardiff, Third Hunter Memorial Lecture, "The Application of Electronics to the Electricity Supply Industry," J. S. Forrest, 6 p.m.

Tues., Dec. 12.—ELECTRONICS AND COMMUNICATIONS SECTION : Savoy Place, London, W.C.2, "Diversity Reception and Automatic Phase Reception," L. Lewin, 5.30 p.m. ★ EAST MIDLAND ELECTRONICS AND CONTROL GROUP : Lecture Theatre, E.M.G.B. Showrooms, Charles Street, Leicester, "Altitude Control of Earth Satellites," B. Stewart, 6.30 p.m. ★ CAMBRIDGE ELECTRONICS AND MEASUREMENT GROUP : Cavendish Laboratory, Free School Lane, Cambridge, "The Banana-Tube Display System—A New Approach to the Display of Colour Television Pictures," P. Schagen, 8 p.m. ★ NORTH WESTERN CENTRE : Engineers' Club, Albert Square, Manchester, 2, "Americanism and Anti-Americanism," Marcus S. Cunliffe, 7 p.m. ★ NORTHERN IRELAND CENTRE : Lecture Theatre LG 25, David Keir Building, Queen's University, Stranmillis Road, Belfast, 9, "Some Notes on the Electrical Requirements of General Cargo Docks," E. R. Radway, 6.30 p.m. ★ SOUTH-EAST SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, "Analysis of Overall Stability of Multi-Machine Power Systems," J. G. Miles, 7 p.m. ★ SOUTHERN ELECTRONICS AND CONTROL GROUP : The University, Southampton, Discussion on "High-Speed Measuring Techniques in the Nano Second Region," opened by B. H. Venning, and D. G. Rollet, 6.30 p.m. ★ SOUTH EAST AND SOUTH WEST SCOTLAND SUB-CENTRES : Carlton Hotel, Edinburgh, "Analysis of Overall Stability of Multi-Machine Power Systems," J. G. Miles and "Electronic Analogue Computer Simulation of Multi-Machine Power System Networks," A. S. Aldred, 7 p.m.

Wed., Dec. 13.—SUPPLY SECTION : Savoy Place, London, W.C.2, "Electrical Aspects of Hunterston Nuclear Generating Station," J. Henderson, G. F. Kennedy and K. J. Wootton, 5.30 p.m. ★ NORTH EASTERN CENTRE : Technical College, Carlisle, "The Protection of High-Voltage Insulators from Power-Arc-Damage," A. E. Guile, 7 p.m. ★ NORTH LANCASHIRE SUB-CENTRE : N.W.E.B. Lecture Theatre, Jubilee Street, Blackburn, "Turbo-Generator Performance under Exceptional Operating Conditions," T. H. Mason, P. D. Aylett and F. H. Birch, 7.30 p.m. ★ SOUTH EAST AND SOUTH WEST SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, Glasgow, "Analysis of Overall Stability of Multi-Machine Power Systems," J. G. Miles, and "Electronic Analogue Computer Simulation of Multi-Machine Power System Networks," A. S. Aldred, 6 p.m. ★ RUGBY SUB-CENTRE : College of Engineering Technology, Rugby, "Electric Traction," J. A. Broughall, 6.30 p.m. ★ SOUTHERN ELECTRONICS AND CONTROL GROUP : C.E.G.B. Offices, High Street, Portsmouth, Discussion on "Silicon Controlled Rectifiers," opened by R. J. Alexander, J. P. Birchenough, and R. Thompson, 6.30 p.m. ★ SHEFFIELD SUB-CENTRE : The University, Sheffield, "Millimetre Waves," J. Allison, 6.30 p.m.

Thurs., Dec. 14.—NORTH SCOTLAND SUB-CENTRE : Department of Electrical Engineering, Queen's College, Dundee, "The Protection of Electrical Systems," H. G. Bell, 7 p.m. ★ WESTERN UTILISATION GROUP AND THE SOUTH WESTERN SUB-CENTRE : Prince Rock Generating Station, Plymouth, "The Organisation of Industrial Electrical Maintenance," S. R. Phelps, 3 p.m. ★ IRISH BRANCH : Physical Laboratory, Trinity College, Dublin, "Production of Electric Motors in Ireland," L. O'Sullivan, 6 p.m. ★ UTILISATION SECTION : Savoy Place, London, W.C.2, "Oscillating Machines—Synchronous and Asynchronous," E. R. Laithwaite and "An Oscillating Synchronous Linear Machine," E. R. Laithwaite and R. S. Mamak, 5.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Dec. 11.—NORTH EAST BRANCH : New Lecture Theatre, Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, 1, "Oil Refining," A. H. Goodliffe, 7.15 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., Dec. 13.—Caxton Hall, Westminster, London, S.W.1, "The Hot Dip Galvanising Process," Morgan H. Davies, 6.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Dec. 12.—39, Elmbank Crescent, Glasgow, "Diesel-Electric Propulsion Equipment in (W.) Germany," H. June and F. Fass, 6.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Thurs., Dec. 14.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "Fire Protection in Buildings," E. A. Hibbitt, 6 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Tues., Dec. 12.—AUTOMOBILE DIVISION : 1, Birdcage Walk, Westminster, London, S.W.1, "Instrumentation Problems of Internal Combustion Engine Development," J. G. G. Hennessy, 6 p.m. ★ NORTHERN IRELAND BRANCH : Central Hall, College of Technology, Belfast, "The Design, Commissioning and Operation of Blyth 'A' Power Station," A. E. Powell and E. Forth, 6.30 p.m. ★ NORTH WESTERN A.D. CENTRE : Co-operation Hall, Warrington, "The Measurement of Tractor Performance," T. C. D. Manby, 7.15 p.m. ★ WESTERN GRADUATES' SECTION : Bristol College of Technology, Ashley Down, Bristol, Films, 7 p.m.

Wed., Dec. 13.—THOMAS HAWKSLEY LECTURE : 1, Birdcage Walk, Westminster, London, S.W.1, "Problems of Commuter Traffic in Conurbations," A. Bull, 6 p.m. ★ YORKSHIRE BRANCH : College of Technology, Huddersfield, "Gear-Tooth Contact Phenomena," H. E. Merritt, 7 p.m. ★ LUTON A.D. CENTRE : Royal Hotel, Luton, "A Theory of Brake Squeal," R. T. Spurr, 7.30 p.m. ★ NORTH WESTERN GRADUATES' SECTION : Visit to Thames Board Mills, Warrington, 6.30 p.m. ★ SOUTHERN GRADUATES' SECTION : Technical College, Basingstoke, "Instrumentation of Vehicle Testing," M. R. Hayes, 7.30 p.m.

Thurs., Dec. 14.—University Engineering Laboratory, Bristol, "Maintenance Experience of the Calder Reactor," J. R. Treharne, 7 p.m. ★ MIDLAND BRANCH : Birmingham and Midland Institute, Paradise Street, Birmingham, Repetition of the Leonardo da Vinci Lecture, "The Challenge of Vertical Take-off : Part 1—Helicopters," G. S. Hislop and "Part 2—Jet Lift," D. Keith-Lucas, 2.30 p.m. and 6.30 p.m. ★ SOUTHERN BRANCH : King and Queen Hotel, Brighton, "Commonwealth Telecommunications," J. A. Smale, 7.30 p.m. ★ DERBY A.D. CENTRE : B.R. Staff College, London Road, Derby, "Design and Development of a Gas Turbine Locomotive," J. O. P. Hughes, 7.30 p.m.

INSTITUTION OF NUCLEAR ENGINEERS

To-day, Dec. 8.—Caxton Hall, Westminster, London, S.W.1, "The Nuclear Propulsion of Ships," Captain Atkins, 2.30 p.m.

INSTITUTION OF PLANT ENGINEERS

Wed., Dec. 13.—EAST MIDLANDS BRANCH : Sherwood Room, County Hall, Theatre Square, Nottingham, "Repairs by the Metalock Process," N. Tinwell, 7 p.m. ★ WESTERN BRANCH : Grand Hotel, Broad Street, Bristol, "Safety in Factories," J. B. Taylor, 7.15 p.m.

Thurs., Dec. 14.—GLASGOW BRANCH : Scottish Building Centre, 425, Sauchiehall Street, Glasgow, C.2, "Shipbuilding To-day," D. B. Kimber, 7.15 p.m. ★ MERSEYSIDE AND N. WALES BRANCH : Exchange Hotel, Liverpool, "Overhead Equipment for Railway Electrification," J. H. Leonard, 7.15 p.m. ★ NORTH EAST BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, 1, "Some Engineering Aspects of Recent Developments in the Iron and Steel Industry," E. F. Wooldridge, 7 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Dec. 11.—EAST AND WEST RIDINGS REGION : Hotel Metropole, King Street, Leeds, 1, "Grinding and Precision Machining Techniques," H. F. Plaut, 7 p.m. ★ NORTHERN REGION : Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, 1, Film Evening, 7 p.m.

Tues., Dec. 12.—EAST AND WEST RIDINGS REGION : Technical College, Waterdale, Doncaster, "Continuous Casting," G. Littlewood, 7 p.m.

Wed., Dec. 13.—NORTH MIDLANDS REGION : Technical College, Lincoln, "Production Engineer, To-day and Tomorrow," F. W. Cooper, 7.30 p.m.

Thurs., Dec. 14.—SOUTHERN REGION : Technical College, Boundary Road, Farnborough, "Practical Applications of Production Engineering Research," D. F. Galloway, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Dec. 8.—MIDLAND COUNTIES GRADUATES AND STUDENTS SECTION : Engineering Centre, Birmingham, "Recent Research in Timber Engineering," I. D. G. Lee, 6.30 p.m. ★ SOUTH WESTERN COUNTIES SECTION : Duke of Cornwall Hotel, Plymouth, "Site Production and Placing of Concrete," R. J. Tatt, 6 p.m.

Wed., Dec. 13.—MERSEYSIDE PANEL : College of Building, Liverpool, "The Construction of a Large Covered Reservoir," J. W. Baron, 6.30 p.m. ★ YORKSHIRE BRANCH : Metropole Hotel, Leeds, "The Doncaster Motorway—Reflections in Retrospect," S. Maynard Lovell, 6.15 p.m.

Thurs., Dec. 14.—11, Upper Belgrave Street, London, S.W.1, "The Chemical and Physical Effects of Aggressive Substances on Concrete," P. E. Halstead, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Dec. 8.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The Development of a Modern Interceptor Aircraft," A. F. Atkin, 7 p.m.

Mon., Dec. 11.—SHEFFIELD AND DISTRICT SECTION : Livesey Clegg House, 44, Union Street, Sheffield, 1, President's Address, 7.30 p.m.

Fri., Dec. 15.—Pepys House, 14, Rochester Row, London, S.W.1, Inaugural Meeting and Presidential Address, "The History and Work of the Railway Inspectorate—Ministry of Transport," C. A. Langley, 7.30 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Dec. 15.—Mining Institute, Newcastle upon Tyne, "Investigations into the Strength of Underdeck Girders Carried Out at Glengarnock," K. V. Taylor and J. S. Shand, 6.15 p.m.

PLASTICS INSTITUTE

Tues., Dec. 12.—SCOTTISH SECTION : Kenilworth Hotel, Glasgow, "The Use of Polymers for Paper Coating," J. R. Young, 7.30 p.m.

RADAR AND ELECTRONICS ASSOCIATION

Thurs., Dec. 14.—Royal Society of Arts, John Adam Street, Adelphi, London, W.1, "Loudspeaker Enclosures," J. Gough and F. Landgrebe, 7 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Dec. 12.—MIDLAND COUNTIES BRANCH : Birmingham and Midland Institute, Paradise Street, Birmingham, "Recent Developments in Prestressed Concrete," B. Rhodes, 6 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN

To-day, Dec. 8.—21, Albemarle Street, London, W.1, "Restless Atoms in Solids," Dame Kathleen Lonsdale, 9 p.m.

ROYAL SOCIETY OF ARTS

Wed., Dec. 13.—John Adam Street, Adelphi, London, W.C.2, "Tin : Its Contribution to Social Development," E. S. Hedges, 6 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Thurs., Dec. 14.—ROAD AND BUILDING MATERIALS GROUP : 14, Belgrave Square, London, S.W.1, Special Meeting on "New Test Methods," 2.30 p.m. and 5.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Wed., Dec. 13.—CONTROL SECTION : Manson House, 26, Portland Place, London, W.1, "Application of Complex Plane Methods to System Design," P. K. M'Pherson, 6.30 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., Dec. 14.—Park Place, Cardiff, "Modern Process Control," O. G. Pamely-Evans, 6 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Thurs., Dec. 14.—39, Elmbank Crescent, Glasgow, "Operating Experience with an 80-ton Electric Arc Melting Furnace," J. M. Mowat, A. G. McMillan and R. McDonald, 6.45 p.m.